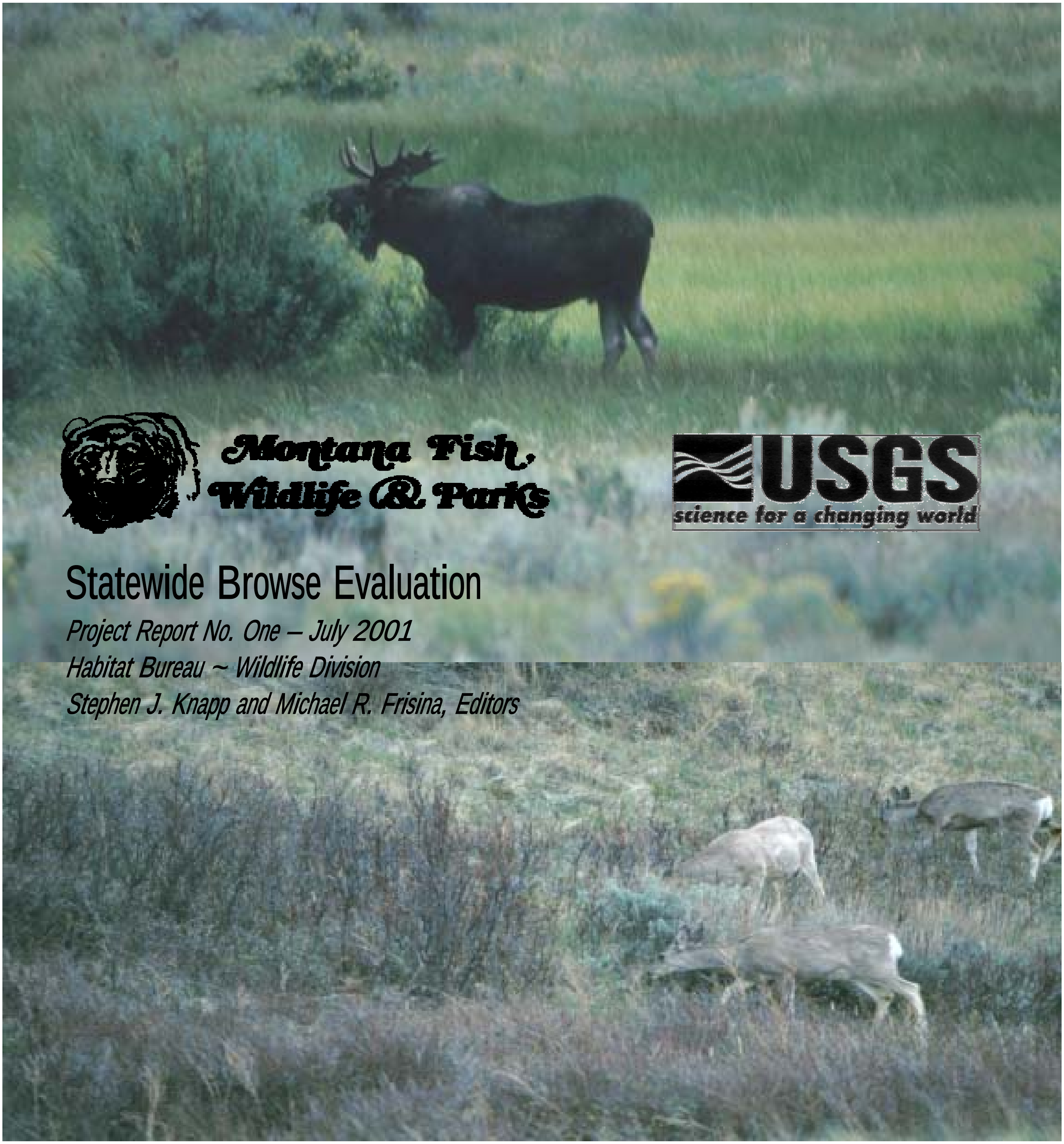


Statewide Browse Evaluation

Project Report No. One – July 2001

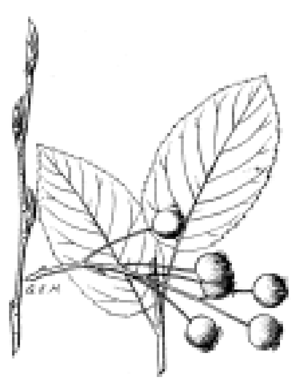
Habitat Bureau ~ Wildlife Division

Stephen J. Knapp and Michael R. Frisina, Editors

Montana Fish, Wildlife & Parks

USGS
science for a changing world

"The idea of controlling environment is the fundamental thing for game management to contribute to the conservation movement. Shooting and all other aspects of game utilization are simply things which become possible when environments are kept favorable."
--Aldo Leopold, 1931



Salix bebbiana (Bebb willow): A-seed capsules; B-flowers; C-mature leaves; D-shoots
Courtesy Hunt Institute of Botanical Documentation, CMU.

Pseudotsuga mensezei (Douglas fir)

Pinus contorta (lodgepole pine)

PROJECT REPORTS

Populus tremuloides
(quaking aspen)

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Potentilla fruiticosa (shrubby cinquefoil)

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INTRODUCTION

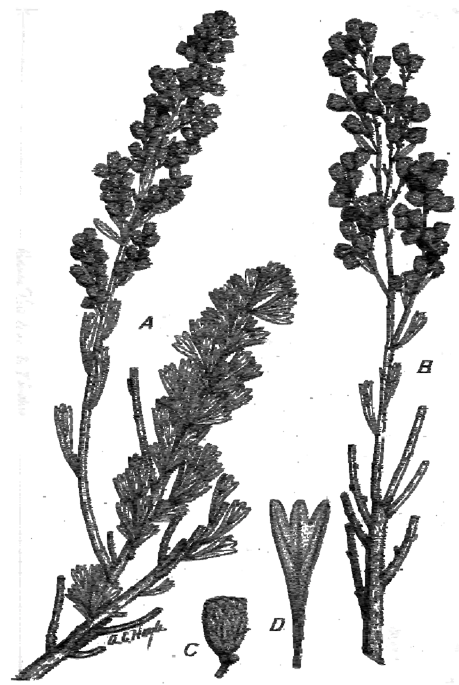
A fundamental mission of Montana Fish, Wildlife & Parks (FWP) is the conservation of fish and wildlife habitat. FWP has used as its primary tools for habitat protection, conservation easements, establishment of Wildlife Management Areas, and contracts with private landowners to protect upland game bird habitat.

Although these tools have protected hundreds of thousands of acres of wildlife habitat in Montana, some Department employees became concerned that perhaps the management of those habitats was not as it should be. The concern centered on what appeared to be intense browsing by large herbivores and its impact on woody vegetation. In some areas herbivores include both wild and domestic animals, but in other places only wild herbivores are present.

A few Department employees met with others to devise a strategy to determine the status of browse in Montana. ***A stated goal was to evaluate the condition and trend of woody plant species across the State of Montana.*** It was decided to develop a method that FWP and

Amelanchier alnifolia (serviceberry) – Botanical illustrations courtesy Hunt Institute for Botanical Documentation, CMU.

others could use to evaluate woody vegetation in relation to herbivore browsing. FWP, United States Geologic Survey, and Rocky Mountain Elk Foundation pooled resources, resulting in the publication,**" Browse Evaluation By Analysis of Growth Form, Volume I: Methods For Evaluating Condition and Trend ", by Richard B. Keigley and Michael R. Frisina.**



Artemisia tridentada (big sagebrush).

This progress report is the first compilation of ongoing efforts to use FWP's browse evaluation methods to determine trends in browse.

In addition, FWP is funding a graduate student from MSU to evaluate woody vegetation by comparing the status of browse plants within established exclosures with similar sites outside the exclosures. This research is being conducted at a number of sites across Montana.

One of the premises of wildlife management is that wildlife habitat has a carrying capacity. Beyond that capacity, wildlife survival becomes precarious. Woody species are much more than a food supply for large ungulates; they provide essential habitat for a variety of other important species like songbirds and small mammals. It behooves wildlife managers to understand habitat carrying capacity; to not allow the habitat capacity to be degraded; and to manage wildlife populations within acceptable habitat limitations. Aldo Leopold said it best –

"The idea of controlling environment is the fundamental thing for game management to contribute to the conservation movement. Shooting and all other aspects of game utilization are simply things which become possible when environments are kept favorable." (Report on Game Survey of the North Central States, 1931).

Browsing History as an Indicator of Range Capacity

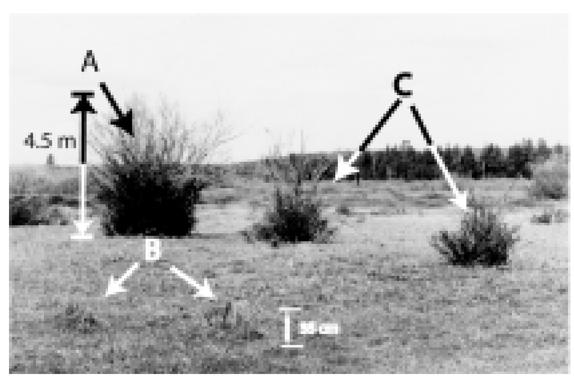
Richard B. Keigley, Michael R. Frisina, and Craig Fager

Introduction

This paper describes how a reconstructed browsing history was used to determine the range capacity of moose (*Alces alces*). The study took place on a portion of the 22,743-ha Mount Haggin Wildlife Management Area (MHWMA) located in southwest Montana about 19 km south of the town Anaconda. The study area consists of a combination of wet and dry meadows. Willows are common along numerous stream courses and wide riparian areas created by beaver dams. Elevation of the study area is about 1900 meters; annual precipitation is about 51 cm.

Prior to 1976, the area was privately owned (Newell and Ellis 1982). Domestic livestock grazed pastures continuously and intensively, and willow (*Salix* spp.) was sprayed, dozer-piled, and burned to create more grassland for livestock. In 1976, the Montana Department of Fish, Wildlife & Parks (FWP) purchased the land and established the MHWMA to provide habitat for wildlife and public recreational opportunities (Frisina 1982). The reduction of willow was stopped, and since 1984, livestock have been managed under a rest-rotation grazing system (Frisina 1992). Populations of moose (*Alces alces*), elk (*Cervus elaphus*), mule deer (*Odocoileus hemionus*), and pronghorn antelope (*Antilocapra americana*) increased (Frisina 1982, Kuntz 1993). Recently, whitetail deer (*Odocoileus virginianus*) began using the study area during the summer.

Moose are the only large ungulate present on the study area during winter; they concentrate in willow bottoms as snow accumulates. Deer, elk, and antelope inhabit the area during snow-free months, when herbaceous plants are generally preferred, and all habitat types are available for foraging. After establishment of the MHWMA, livestock numbers were reduced and a rest-rotation grazing system was established. Cattle were allowed access to a pasture during the growing season once every third year (Frisina 1992).



In recent years it has been noted that young willows were browsed to hedges about 35 cm tall. Growing beside these shrubs were older willows up to 4.5 m tall. The older willows must have attained much of their height when browsing was less intense. The difference in growth forms indicates that there has been an increase in browsing pressure sometime between the establishment of the older and younger willows.

Moose appear to be primarily responsible for the increase in browsing pressure. The role of moose is indicated by heavy browsing in a pasture from which livestock have been excluded since 1984. In addition, over the period 1976 to 2000, the moose population increased 8-fold, from 7 to 56 censused.

Ungulates browse at a variety of heights above ground level. Browsing close to ground level likely occurs early in the snowcover season (Keigley 1997a). The hedging of MHWMA willows at 35 cm likely occurs at this time. As deeper snow accumulates, moose must rely on taller stems. At MHWMA, snow can accumulate up to 2-m-deep. Moose continue to utilize willow by moving through deep snow or on top of crusted snow.

If present trends continue, young willows will not grow 4-5 m tall. Over time, the willow community will be converted to a meadow. Under these conditions, MHWMA will no longer function as winter range.

The change in growth forms (from older full-statured plants to young, hedge-like plants) indicates that, as the population increased 8-fold, moose exceeded range capacity. The objective of this study was to determine that range capacity by: a) identifying when range capacity was exceeded, and b) determining the number of moose that were present at the time. Moose winter censuses have been regularly conducted from 1976 to the present. The number of moose present was determined from those data.

To determine when range capacity was exceeded required the reconstruction of the browsing history at MHWMA. History reconstructions have been inferred from the comparison of photographs taken at various points in time (Wright and Thompson 1935, Houston 1982, Kay 1990). However, photograph-based interpretations are limited to years and sites for which photos were taken. This paper describes an alternative method for determining when browsing level increased. The method is based on a dendrochronologic analysis of plant growth form and does not depend on the acquisition of data from previous years.

Methods

The method is based on browsing-related architectures described in Keigley (1997a, 1997b) and Keigley and Frisina (1998). The architectures are produced when the terminal leader is within reach of ungulates. We distinguish between two browsing levels: a) light-to-moderate, and b) intense. Under light-to-moderate browsing, current-year-growth develops from the previous-year's growth. The intense level is defined to occur when browsing causes the death of a complete annual segment. In this case, current-year-growth develops from a segment that is older than the previous-year's-growth.

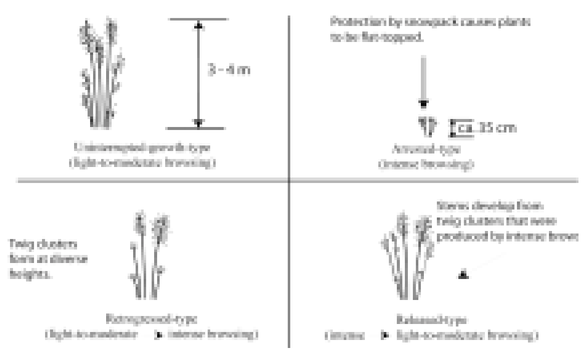
Four architecture-types are produced by four browsing regimes:

1) Uninterrupted-growth-type architecture (light-to-moderate browsing as the terminal leader grows through the browse zone),

2) Arrested-type architecture (intense browsing),

3) Retrogressed-type architecture (a change from light-to-moderate browsing to intense browsing), and

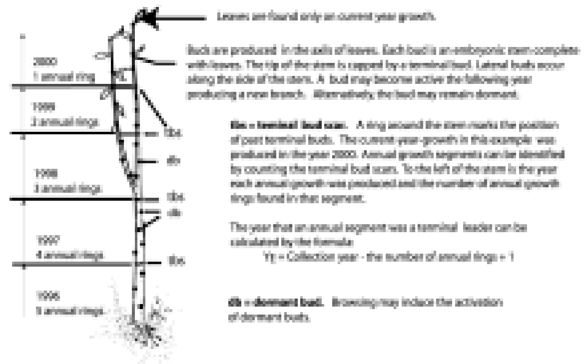
4) Released-type architecture (a change from intense browsing to light to moderate browsing).



In general, a plant's architecture reflects the browsing level that existed when the plant was young. At a given site, similar-aged plants of the same species should have experienced a similar level of browsing and have the same architecture. Plants of different age may have different architectures, but should express a consistent history. For example, at a site that experienced an increase in browsing pressure, one would expect to find young arrested-type plants and older retrogressed-type plants. Given the difference in plant ages, both architectures are consistent with an increase in browsing pressure. The architectures of the MHWMA willows shown in the photograph on page 5 indicate such a history.

From dendrochronology, we can often determine the actual year in which a given stem was browsed intensely for the first time. The basis for determining this year is described below.

Twig clusters



In the absence of disturbance such as browsing, stem segments produced during a given growing season develop from stem segments produced the previous growing season. The young stem segment may develop either from the previous-year's terminal bud or, if that bud aborted, from lateral buds slightly lower down the stem. Browsing removes the terminal bud insuring that, if subsequent growth occurs, it must arise by activation of a lateral bud. The stem dies between the point where it was bitten and the point where the new growth emerged. Ungulates typically consume stems produced during the most recent growing season (current-year-growth). If they repeatedly consume a minor portion of the current-year-growth, the stem grows in a zigzag manner, with dead stubs located at intervals on the stem.

Under heavy browsing pressure, ungulates may consume major portions of current-year-growth, often removing material down to the point of the dead stub produced earlier. Because the dead stub is tough and unpalatable, it mechanically protects current-year-growth beneath it. If ungulates repeatedly browse current-year-growth to a point even with the dead stubs from preceding years, a compact cluster of twigs forms .

Stem dieback

After a twig cluster forms, current-year-growth may develop from lateral buds on the stem well below the cluster. For a time, both the twig cluster and the new growth below it may remain alive. Continued browsing will cause the twig cluster to die, and the stem below it will die back to the point where the new growth developed. In the final stages of dieback, current-year-growth may originate close to the base of the original stem; the original stem above that point dies. Over a period of years, a heavily-browsed shrub may produce a succession of stems, each of which dies back to ground level. Eventually, the entire shrub may die.

Determining the year that a stem elongated

Dendrochronology can be used to determine the year in which a particular segment was a terminal leader. For a stem segment collected from the beginning of a growing season through the end of the calendar year, the formula is:

$$Y_E = \text{Collection year} - A + 1,$$

where Y_E is the year that the stem elongated and A is the number of annual rings in the stem segment. For example, if one were to section a current-year-growth segment collected in August 2000, one would find a single annual ring. The year of elongation is:

$$Y_E = 2000 - 1 + 1 = 2000.$$

The +1 corrects for the annual ring produced during the current calendar year. To determine the year of elongation when the stem segment is collected the calendar year following the last growing season (e.g., in February), the +1 correction would not be made. In all cases, the stem segment must be live at the time of collection.

Determining the year that browsing pressure increased

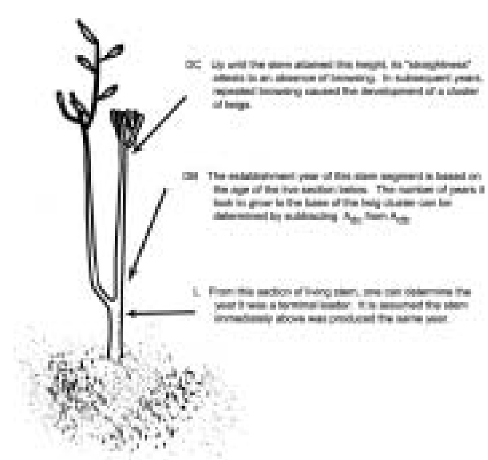
Two methods were used: a) the twig cluster method, and b) the linked-stem method. The twig cluster method is applicable to stems with live twig clusters. The linked-stem method may be used after the twig cluster dies as long as some portion of the stem remains alive.

Twig cluster method. Stems of the type shown in the stem photograph above represent two periods: a period of light-to-moderate browsing (in which the lower stem grew straight) and a period of intense browsing (in which the cluster of twigs formed). If the cluster is alive, the age of the stem just below the cluster indicates the last year in which the terminal leader grew under light-to-moderate browsing. By determining the year that the segment was a terminal leader, we can calculate the year in which browsing pressure increased (Y_I). The formula is:

$$Y_I = [\text{Collection year} - A_C + 1] + 1.$$

In this case, the +1 in the bracketed term corrects for the fact that an annual ring was produced during the calendar year of collection. The correction would not be made if the collection was made the next calendar year and before the next growing season. The second +1 correction is made because the section was taken from the last stem segment produced under light-to-moderate browsing. The stem at the base of the twig cluster is deemed to have been light-to-moderately browsed because it remained alive long enough to produce a cluster; Keigley and Frisina (1998) use complete mortality of an annual segment as the indicator of intense browsing. Browsing level is assumed to have increased to intense the next calendar year.

Linked segment method. If browsing kills the twig cluster, one or more live secondary stems below the twig cluster must support the primary stem if it is to remain alive. Because the twig cluster is dead, the number of annual rings at its base can no longer be referenced to the collection year. To relate the development of the twig cluster to the collection year, one must link the annual rings at its base to a stem segment that was alive at the time of collection.



The onset year of intense browsing is determined from three stem sections:

1. A section taken of the primary stem just below the point where the live secondary stem originates (L) in the figure. The year that this stem segment was a terminal leader is determined from the number of

annual rings. Ring development in section L may be asymmetrical depending on how close the section is to the dead primary stem above it; when counting annual rings, care must be taken to include those produced during the most recent growing season.

2. A section of the dead primary stem immediately above the point where the live secondary stem originates (DB in the figure above). An assumption is made that the stem at point DB was a terminal leader the same year as at point L. When making collections, the length between points L and DB is typically 2 - 5 cm, so it is likely that the sections were produced the same growing season.

3. A section at the base of the dead twig cluster (DC). The difference in the number of annual rings in sections DB and DC indicates the number of years it took for the stem to grow to the base of the cluster. It is assumed that cluster formation began the following year.

The year of twig cluster formation is calculated as follows:

$$Y_I = [\text{Collection year} - A_L + 1] + [A_{DB} - A_{DC}] + 1.$$

The first bracketed term indicates the year that the linking section was a terminal leader; A_L is the number of annual rings in the linking segment. As above, +1 may or not be added depending on when the collection was made. The second term, $[A_{DB} - A_{DC}]$, indicates the number of years it took the stem to grow to the base of the cluster. The first two terms added together indicate the year that the stem at the base of the cluster was a terminal leader. As above, the second +1 correction is added because browsing intensity is assumed to have increased the year after the stem grew to point DC.

Sample sites and selection of stems

Using the methods described above, the onset year of intense browsing was determined at each of six sample sites (see map on page 5). Each sample site was approximately 0.2 ha in area. The sites were located on segments of Deep Creek, Sullivan Creek, and Dry Creek, and were distributed along a total distance of 3 km. Elevation ranged from 1,820 m at Site 1 in the south, to 1,890 m at Site 6 to the north.

At each site, we sampled a stem from each of 20 Geyer willow (*Salix geyerianna*) plants. We preferentially sought stems bearing dead twig clusters 75 – 200 cm above ground level. Twig clusters were inspected for bite marks to insure that the cluster formation and stem death occurred from browsing and not from other causes such as insect infestation, freezing, and flooding. These stems were analyzed by the linked-segment method. Where enough dead-twig-cluster-bearing stems could not be located within the sample site, live twig-cluster-bearing stems were included in the sample. These stems were analyzed by the twig cluster method.

The twig-cluster height range criterion was based on the following. Stems established after the increase in browsing pressure would have been protected from browsing until they grew taller than the protection of snowcover (Keigley 1998). Twig clusters of such plants would not accurately indicate when the increase in browsing occurred. Twig clusters from the stems of plants that were mature when browsing pressure increased were also rejected. Those twig-cluster-bearing stems may have originated from within the interior of the shrub and may have been mechanically protected by mature stems until they grew beyond that protection. Plants on which the tallest twig clusters were 75 – 200 cm above ground level would presumably have grown beyond the protection of snowcover, when browsing pressure increased, and would not have been mechanically protected by taller stems. Where enough stems within this size range could not be located within the site, shorter stems were selected. The effect of including short stems and stems with live twig clusters was analyzed by comparing the results of the full data set with results obtained when plants not meeting the above criteria were removed.

The height of the live stem (H_{pyg}) was measured from ground level to the base of current-year-growth. We measured the height to the top of the dead twig cluster or, in the case where some twigs in the cluster were alive, the height to the tip of dead twigs in that cluster (H_d). On stems with dead twig clusters the stem was sectioned at L, DB, and DC (see figure on page 8 for explanation of symbols). On stems with live twig clusters, a section was taken at the base of the twig cluster. The age of each section was determined by counting annual rings.

Moose population trend

The study area lies within FWP moose Hunting District 325. Moose population data collected during complete winter aerial surveys of Hunting District 325 from 1964 through 2000 were used to determine population trend. These data represent the actual number of moose observed which is less than the total number of moose in the population (Anderson and Lindzey 1996).

Results and discussion

Determination of the year of increased browsing

From a dendrochronologic analysis of browsed stems, the year in which stems were first intensely browsed was determined at six study sites in the MHWMA. The average onset year of the pooled data was 1985.4 ± 0.5 SE (Tab. 1). A comparison by ANOVA found significant differences among sample site means ($P = 0.002$). Those differences were contrasted by a post-hoc Bonferroni test at $P < 0.05$.

Table 1. Location of sample sites, number of sampled stems at site that were less than 75 cm tall, measurement method, year intense browsing began, and lifespan of heavily browsed twigs. Stems less than 75 cm tall did not completely meet selection criteria. Measurement method is described as the ratio of those determined by the Twig Cluster Method (TCM) to those determined by Linked Segment Method (LSM). Plants measured by the TCM did not completely meet selection criteria. The sample number of Y_I and A_{DC} is equal to the number determined by LSM.

Site	Stems < 75 cm	Method	Y_1	± SE	A_{DB}	± SE
1	1	2:18	1986.9	± 0.7	10.6	± 0.5
2	1	0:20	1988.4^{ab}	± 0.9	8.2^{ab}	± 0.7
3	2	2:18	1983.1^{a}	± 1.5	10.2	± 0.8
4	3	0:20	1983.7	± 0.9	11.4^{a}	± 0.5
5	4	0:20	1986.9	± 1.1	10.1	± 0.7
6	0	0:20	1983.6^{b}	± 1.3	11.5^{b}	± 0.7

Means with the same superscript letters differed significantly at $P<0.05$

The formation of twig clusters indicates when a stem was first exposed to intense browsing. In the case of the oldest stems, twig cluster formation indicates a site-wide increase in browsing pressure. In the case of younger stems, twig cluster formation may indicate when the stem grew taller than some means of mechanical protection such as snow cover. Out of the total sample in this study, 116 dates were obtained from old stems in which the twig clusters were dead (analysis was by the linked-stem method); these stems were presumed to reflect the site-wide increase in browsing pressure. Four dates were obtained from live twig clusters. We were concerned that, by using dates from live twig clusters, we might be inadvertently documenting growth beyond mechanical protection, and therefore biasing the result to yield a more recent onset date. We examined the effect of including live twig cluster data by excluding those data. The resulting onset date was identical: 1985.4 ± 0.5 (± SE).

The average age of the stem at the base of the dead twig clusters was 10.2 ± 0.3 years (± SE). This age suggests that live twig clusters may reliably indicate the onset of intense browsing for periods up to about 10 years. To document an onset of browsing that occurred more than 10 years in the past, one should sample stems with dead twig clusters and determine the onset date by the linked segment method.

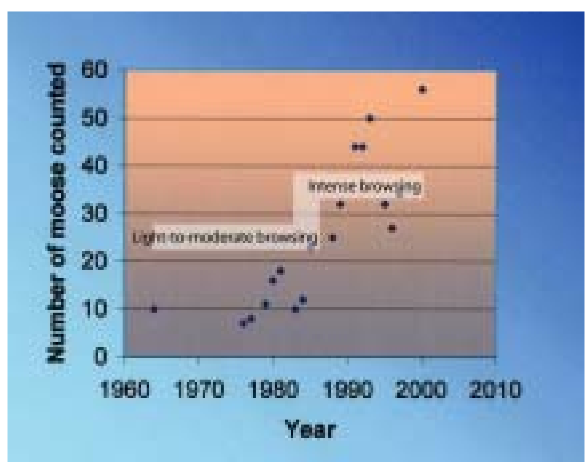
We were also concerned about the potential effect of including plants less than 75 cm tall because such plants might be too young to accurately reflect the earliest increase in browsing pressure. We examined the effect of including 11 such plants by excluding them from the data set. The resulting analysis yielded a mean onset year of 1985.4 ± 0.5 SE, a value identical to those above.

Interpretation of the data

Up until 1984, both livestock and wildlife had access to all sites. In 1984, livestock were prevented from grazing at Site 1. The increase in browsing that occurred in Site 1 in 1987 must have been due to wild ungulates.

Beginning in 1984, a rest-rotation grazing system was established that lessened the impact of livestock. The increase in browsing at Site 1 (in the absence of livestock) in combination with establishment of the rest-rotation grazing system suggests that wild ungulates, specifically moose, played an important role at all 6 sites. The average onset years for intense browsing (1983 – 1988) coincide with the period in which the HD 325 moose population was increasing most dramatically.

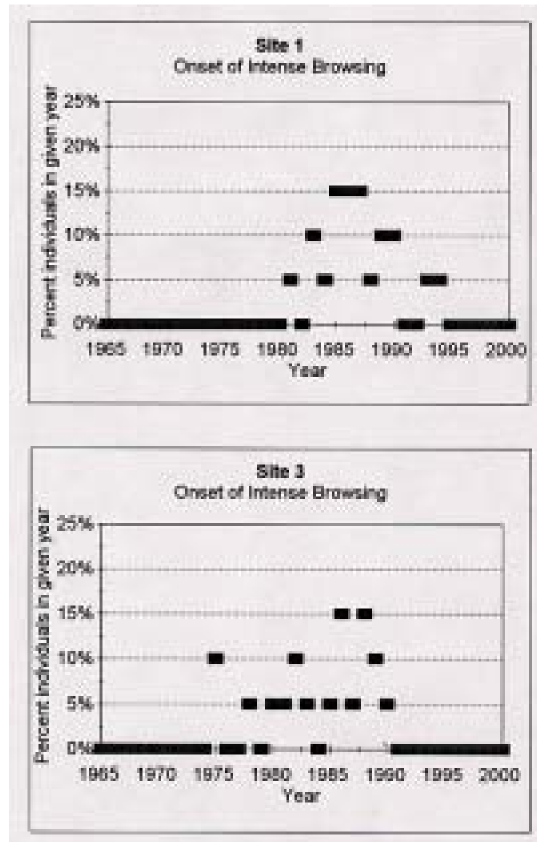
In the mean onset year of 1985, 23 moose were counted. We believe that the range has the capacity to support about that number of moose without causing a decline in willow. In 2000, 56 moose were counted during the winter census. It is important to recognize that these figures refer to a census number, with the actual number of animals present being somewhat greater.



To change from intense to a light-to-moderate browsing intensity may require reductions in the moose population below 1985 observed levels due to the duration and severity of intense browsing. Such reductions would require careful monitoring of both willow and moose.

The increase in browsing did not occur abruptly; at a given site some plants were intensely browsed before others. The figure to the right shows the temporal distribution of increased browsing at Sites 1 and 3, where the standard errors were least and greatest, respectively. With the exception of Site 3, the standard errors generally increased from lower in the drainage to the upper part of the drainage (e.g., 0.73 at Site 1 to 1.1 at Site 6). In part the differences may be an artifact of sample selection, but the variation may also indicate the time span over which ungulates began to impact the willows.

The down-drainage trend in variance suggests that moose may have exploited the upper drainage first. Two events likely occurred simultaneously: 1) the moose population increased, and 2) the quantity of browse in the upper drainage declined. This combination may have encouraged exploitation of areas down the drainage. As a result, the increase in intense browsing at Site 1 appears to have occurred over a relatively brief span of time.



Management Implications

The management of riparian habitats is currently a controversial issue, especially in western North America, and the use of these areas by large ungulates, both wild and domestic, is often central to the issue. Our method for determining the year that intense browsing began provides managers with a tool useful, when used in combination with other information such as population survey data, to reconstruct a browsing history for making informed management decisions.

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Assessing Browse Trend at the Landscape Level

Richard B. Keigley, Michael R. Frisina, and Craig Fager

Introduction

Woody plants are an important habitat component of rangelands. They provide food and shelter for animals that range in size from moose to warblers to insects. Woody plants modify the local climate, creating conditions that allow plant species to grow that might not otherwise be present. Nevertheless, while their importance is widely recognized, the condition of woody plants is often a secondary concern of land managers.

In part, this situation occurs because a willow shrub lacks the charisma of a bull moose. In part, the situation occurs because the development of browse-related management techniques lags behind the development of techniques relating to, for example, the management of a moose herd. A number of methods have been developed to measure browse condition and trend, including percent-twigs-browsed, biomass removed, and the analysis of growth forms. However, all too often, browse data are not collected. Perceptions about browse condition and trends are often a product of gut-level impressions.

There are good reasons why browse data are not collected. First, managers may perceive the ecological and political issues as being overwhelmingly complex. Typically, more than one ungulate species is involved, and often the ungulates occupy different ranges at different times of the year. Managers of rangelands are not only responsible for the condition of their rangelands, they must also contend with the fact that ungulates often migrate across multiple political jurisdictions, each of which is subject to different management practices. With these complexities, even the beginning step of data collection might be abandoned.

Second, some of the methods, such as determining the percent-twigs-browsed, require that a manager spend a great deal of time in a small area before a usable dataset is acquired. Under these circumstances, acquiring data at the landscape level is unrealistic. Managers simply lack the time required to collect data.

Third, the data collected do not necessarily indicate if the browsing is at acceptable or excessive levels. For example, determining the percent-twigs-browsed tells the manager something about the level of herbivory, but without a separate study to document the physiological effects of that herbivory, the manager cannot be sure how browsing will affect the willow community. It is likely that this lack of certainty lessens some manger’s enthusiasm for data collection. The lack of certainty also influences the manager’s ability to explain management decisions to interested parties, including other resource managers, grazing permittees, environmental groups, and sportsman’s groups.

Given the problems described above, the collection of browse data may become a daunting project for which the manager cannot find time. There are ways to improve the situation. Complex issues can be simplified by focusing on key areas and indicator species. Data collection can be made more efficient by adopting an approach that, in the near term, provides managers a basis for management that, over the long term, can be refined by additional data collection. The link between browsing and its ecological effect can be made more apparent. We describe a systematic approach that incorporates these qualities. The approach is illustrated with a case study.

Study area

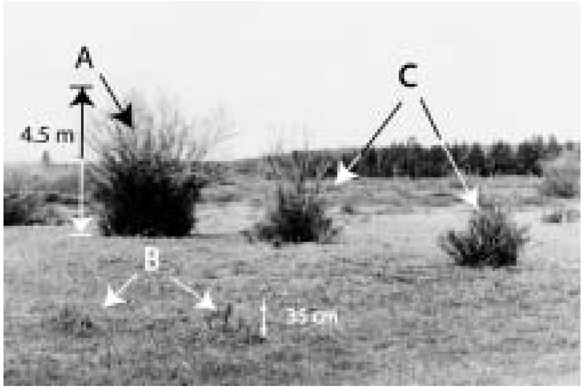
The case study was conducted on the 22,743-ha Mount Haggin Wildlife Management Area (MHWMA), located in southwest Montana about 19 km south of Anaconda. Winters are extremely cold and windy. The annual precipitation is about 50 cm, much of which occurs as snow.

There are resident and transient ungulate populations. Moose is the only ungulate species present in all months. Elk, mule deer, and pronghorn antelope are present much of the year, but cannot contend with the deep snowcover that exists during mid-winter. Whitetail deer and cattle are present during the warm season. Cattle are managed under a three-pasture rest-rotation grazing system.

During the fall, a significant transient moose population occupies the study area. As snowcover deepens in the Pintler Mountains to the west, moose migrate from those mountains and stage in the study area before migrating to lower elevation winter range in the Big Hole Valley. Over the past three decades, the moose population has increased. Censuses by Montana Fish, Wildlife & Parks in the 1970s reported an average of 9 animals; in 1980s, an average of 19 animals was reported; in the 1990s, an average of 39 was reported.

Willows present in the study area include Geyer, Drummond, Booth, planeleaf, Scouler, and Wolfs willow. The riparian species are found in two general kinds of valley bottoms. At the lower end of the drainage, the valleys tend to be wide and flat-bottomed, and locally bordered by glacial moraines. Within some of the flat-valley-bottom areas, willow communities are confined to the corridor immediately adjacent to relic or current stream courses. At other locations, ponding caused by beaver dams has allowed willow communities to spread across a broad area. At the upper end of the drainage, willows are confined within relatively narrow, v-shaped valleys. In the upper drainages, conifers often are present within the willow community. Willows are heavily browsed.

The following evidence indicates that browsing pressure has increased over the years. Heavily browsed 35-cm-tall plants grow in close proximity to 5-m-tall plants, the tallest stems of which are unbrowsed. The 5-m-tall plants are older than the 35-cm-tall plants, and apparently grew through the browse zone when browsing pressure was lower than its current level.



Willows are clearly an important resource at Mt. Haggin. It also is clear that ungulate browsing is affecting the growth of willows. For those reasons, a program was initiated to assess the trend of Mt. Haggin's willows. The program entails five steps:

1. Identify management objectives pertinent to the browse resource.
2. Define the desired resource condition for browse plants.
3. Select an indicator species.
4. Map the distribution of that species.
5. Assess the trend of plants growing in areas that are important to ungulates.

Management objectives

The management of Mt. Haggin's browse resource is guided by two factors. First, the area was purchased to provide winter range for big game. To serve as winter range, browse plants must be available for ungulate use under snowcover that ranges from negligible, early in the winter season, to more than 1-m-deep in mid-winter. In addition, Montana Fish, Wildlife & Parks is committed to providing habitat for a variety of game and nongame wildlife. For example, Mt. Haggin WMA provides nesting habitat for sandhill cranes and neotropical migrants. To accomplish these management objectives will require the presence of appropriately-sized woody plants. At Mt. Haggin, willows range in height from very small, young plants, to older plants more than 5-m-tall. The preservation of this diversity in plant heights is essential to meeting the management objectives.

Desired condition

As indicated by the management objectives described above, we identified the following desired condition: *Plants of diverse height will be present, ranging to the full height potential as determined by local environmental conditions.* This statement forms the basis for browse management at Mt. Haggin. If ungulate browsing is found to prevent plants from attaining full stature, then the range cannot support the ungulate populations that are present. If plants can attain full stature, then the ungulate population is within range capacity.

Indicator species

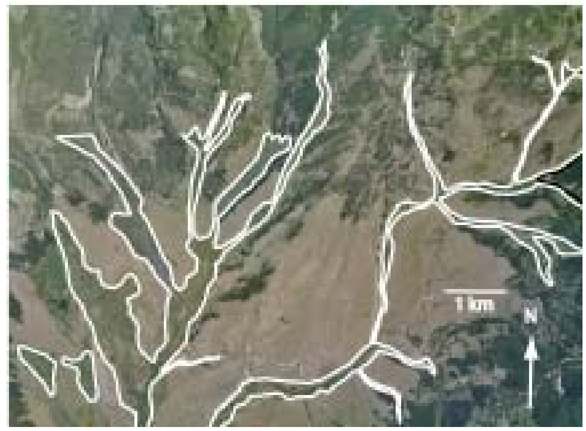
We simplified the data collection problem by focusing on a single indicator species. The indicator species should have two characteristics. First, it should be a browse species that is preferred by ungulates. A highly-preferred species (such as dogwood) is a more sensitive indicator of browse impacts than less-preferred species (such as spruce). Second, the indicator plants should be widely distributed across the managed area. From this distribution, managers can determine how browsing impacts may vary across the landscape.

We selected Geyer willow as the indicator species. At Mt. Haggin WMA, Geyer willow is one of the more-preferred browse plants. Geyer willow is distributed along the total elevation gradient represented in the study area.

We assume that the fate of other browse species is indicated by the trend of Geyer willow. If Geyer willow is in decline, the decline of more-highly preferred species would already have occurred. As the amount of available Geyer willow diminishes, less-highly preferred browse species would also decline.

Delineating the distribution of the indicator species

We prepared a map on which we estimated the total distribution of Geyer willow in the study area. We used the map to prioritize the subsequent steps of field surveying and monitoring. The map was based on a combination of site visits and by examining willow canopy cover on 1:12,000 aerial photographs. From site visits, we determined that Geyer willow extended across the full elevation range included in the study area. This elevational distribution implied that, if any riparian willows were present in an area, Geyer willow plants would likely be included.



Because the map was to be used primarily for prioritizing future work, it was not necessary that the willow community boundaries be precisely drawn. In our case, high quality aerial photographs made the job relatively simple. This step could also be accomplished using images downloaded from the Internet or by delineating the approximate community boundaries on a topographic map.

Assessing trend

Trend was assessed using two approaches: field surveys and monitoring. During surveys, qualitative-type data (browsing-related architecture) are collected. Emphasis is placed on covering a broad geographic area. Because the data are qualitative, they are not amenable to many kinds of statistical analysis. Survey data indicate whether or not plants have been able to grow through the browse zone in recent years, and so, provide managers an immediate indication of trend.

Quantitative-type data (stem heights and growth rates) are collected during monitoring. The data are collected periodically from specific sites (as opposed to a broad geographic area) and are amenable to statistical analyses such as ANOVA. As above, the data provide managers an immediate indication of trend.

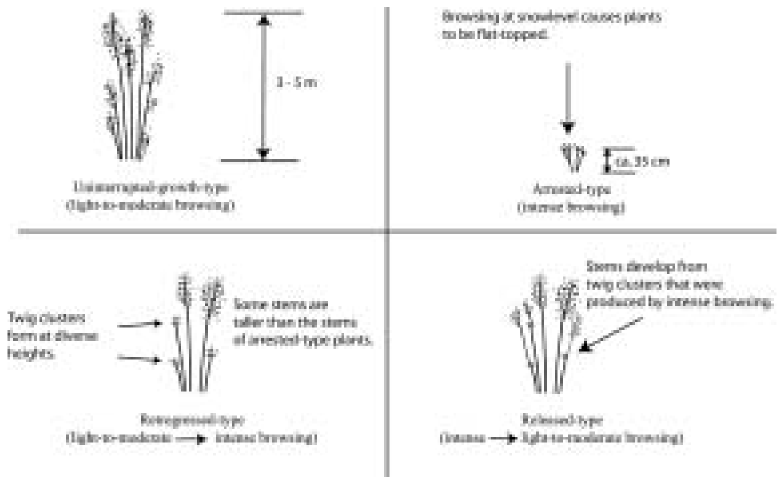
The three types of data (architecture-type, stem height, and growth-rate) complement one another. Managers can emphasize one type of data over another to suit their needs. If it is most important to determine how browsing level might vary across the landscape, the manager can emphasize the survey component. Alternatively, managers wishing to track short-term changes in browsing impacts can do so with the quantitative-type data collected during monitoring.

Field surveys

Field surveys document two aspects: a) browsing level, and b) plant height. Browsing level is an indicator of trend. Plant height indicates the availability of browse during winter. And if the community is in decline, plant height provides a rough indication of persistence. Tall willows with some unbrowsed terminal leaders appear to live longer than shorter willows in which all terminal leaders are heavily browsed.

Below, we describe two field surveys, one conducted on a segment of Sullivan Creek, the other on a segment of Deep Creek. Both areas contain willows that range in height from very short, young plants (e.g., 20-cm) to older plants that are more than 5-m-tall. Short (young), heavily browsed plants grow side-by-side with tall (older) plants. This suggests that the older plants grew to 5-m-tall when browsing was less intense. The increase in browsing pressure is consistent with the increase in the moose population that occurred over the past 3 decades.

Browsing level. Two levels of browsing are distinguished: a) intense, and b) light-to-moderate. Browsing levels in the field are classified by the browsing-related architectures presented in Keigley and Frisina (1998): *Browse evaluation by analysis of growth form*. The architectures are produced during the period of time that the terminal leader grows within the browse zone. In Keigley and Frisina (1998) we present specific rules for determining if a stem is intensely browsed. Browsing level is also evident in a plant's growth form (architecture). There are four browsing-related architecture-types:



a) Uninterrupted-growth-type (produced under light-to-moderate browsing conditions),
b) Arrested-type (produced by intense browsing),
c) Retrogressed-type (produced by a change from light-to-moderate browsing to intense browsing), and
d) Released-type (produced by a change from intense browsing to light-to-moderate browsing).

We examined the architecture of plants with terminal leaders in the browse zone. At Mt. Haggin, the browse zone extends from a lower limit of about 20 cm above ground level to an upper limit of about 2.5 m. Plants are apparently browsed at 20 cm early in the winter season as snow begins to accumulate. Later in the winter, taller stems are protected as snow accumulates. The upper limit of the browse zone is controlled by ungulate reach. Stems greater than about 1.5 m may be out of direct reach of deer and livestock; elk and moose can reach upwards of 2.5 m. Browsing at heights greater than those upper limits can occur when ungulates stand on crusted snow, stand on hind legs, or bend stems to the ground.

We characterized the level of browsing by examining the architecture of plants in which the base of the terminal leader was 75-150 cm tall. Plants in this height range likely were exposed to browsing during recent winters.

We distinguished between two situations: a) *all* plants exposed to browsing have arrested- or retrogressed-type architecture (mapping unit: "100% intensely browsed"), and b) *some* plants exposed to browsing have uninterrupted-growth- or released-type architecture (mapping unit: "<100% intensely browsed"). In the case where all plants have arrested- or retrogressed-type architecture, it is probable that no young plants will attain their potential height. In the second case, some plants apparently will attain full stature, and the desired condition will be maintained or attained.

As we traversed the field survey area, we delineated the willow area on an aerial photograph. We partitioned that area into the two mapping units described above. As we moved through an area, we sought out plants that might have uninterrupted-growth- or released-type architecture. When such plants were found, we tried to determine why they had escaped browsing. If a plant was deemed to have escaped browsing because of local protection, we discounted the architecture of that plant as an indicator of area-wide browsing pressure. Local protection of a young plant might occur when a taller neighbor inhibits ungulate access, either directly or by creating a deep snowdrift. When these circumstances were confined to a few square meters, we assumed that the protective effect was temporary.

Plant height. Plant height was documented by narrative description in the Sullivan Creek survey and by mapping in the Deep Creek survey. In the Sullivan Creek survey, we described the general circumstances under which willows greater than 3-m-tall were found.

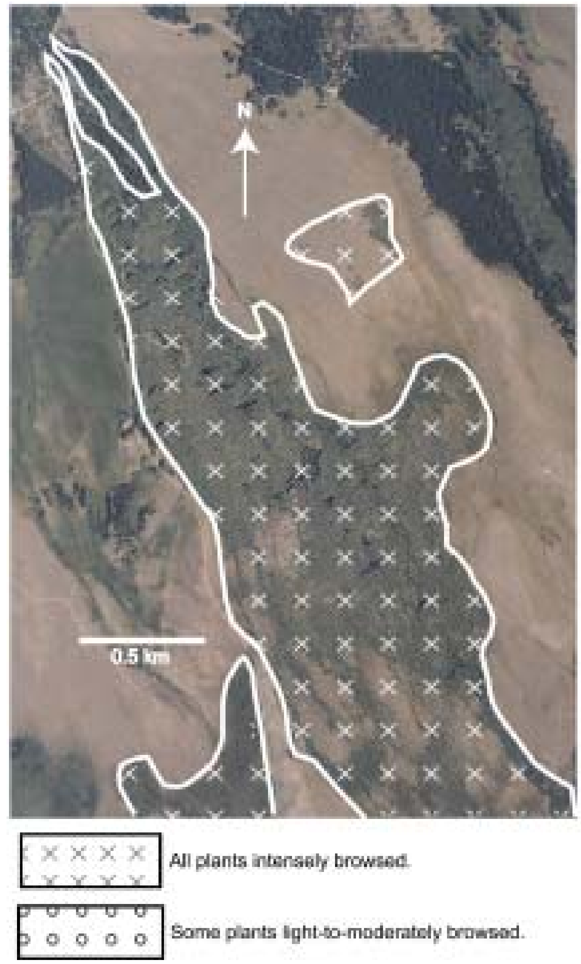
In the Deep Creek survey, we distinguished between three plant-height categories: a) Short (the plant is < 50 cm tall, symbolized by “S”), b) Intermediate (between 50 cm and 3 m tall, symbolized by “I”), and Tall (> 3 m tall, symbolized by “T”). Plant-community height characteristics were described using combinations of the three categories: S, I, T, SI, ST, IT, and SIT. For example, a community composed of willows less than 50 cm tall and willows greater than 3 m tall would be designated ST. A site that has experienced protracted intense browsing may be composed entirely of plants in the S category. During the winter, plants in the S category often are buried by snow and unavailable to ungulates. Plants in the I and T categories are a source of browse under diverse snowcover conditions.

Category T was distinguished because stems greater than 3-m-tall often escape browsing.   The presence of tall terminal leaders might allow a shrub to persist longer than shrubs that solely consist of shorter terminal leaders that are all heavily browsed.   As in the mapping of browsing level, the total willow area was delineated on an aerial photograph and partitioned—as we traveled across the area—into the 7 mapping units listed above.

Deep Creek field survey. The surveyed segment was about 1 km long; willow covered 110 ha (270 acres). The entire area was classified as 100% intensely browsed. As above, the few uninterrupted-growth type plants were growing in vicinity of taller, heavily browsed, neighbors. We assumed the mechanical protection was temporary.

Stands that included willows greater than 3-m-tall constituted 33% of the total willow area (36 ha) (Fig. 4). The remainder of the area (i.e., 67%) consisted of willows that ranged in height from ca. 20 cm to 2-to-2.5-m-tall. While we currently have no basis for quantitatively predicting the rate of decline, we do know that 67% of the willow area is susceptible to a relatively rapid rate of decline.

Sullivan Creek field survey. The surveyed segment of Sullivan Creek was about 3.5 km long, willow covered 230 ha (570 acres). The entire area was classified as 100% intensely browsed. Uninterrupted-growth-type plants were uncommon. In each case, we could identify how the plant was mechanically protected from browsing. If current browsing pressure continues, the protection will be temporary. As the plants adjacent to the uninterrupted-growth-type plants die, moose will focus on the remaining live plants.



Willows greater than 3-m-tall grow in linear zones along current and relict watercourses. Linear zones of tall willows are also associated with beaver dams. Many of the ponds have drained, allowing willows to become established there; these willows range in height from about 20 cm to 2-m-tall. Willows could have become established on the beaver dams when the ponds were still filled with water, so in part, willows growing on the dams may be taller because they are older than willows growing on the former pond areas. In part, the difference in height might be due to heavier browsing of willows growing in the pond areas. A dendrochronologic analysis of stems indicates that browsing pressure increased in the mid-1980s. Willows established since the 1980s would have experienced intense browsing while the tallest terminal leaders were within the browse zone. There is extensive mortality of shorter willows.

Monitoring

Trend was monitored at selected locations by three methods:

1. Repeat photography.
2. The height relationship between live stems and the height of stems killed by browsing (LD Index).
3. Net annual stem growth rate ($NAGR_{L3}$).

The photography provides an assessment of trend from the comparison of photographs taken at intervals of a few years. The LD Index and $NAGR_{L3}$ measurements provide an immediate assessment of trend.

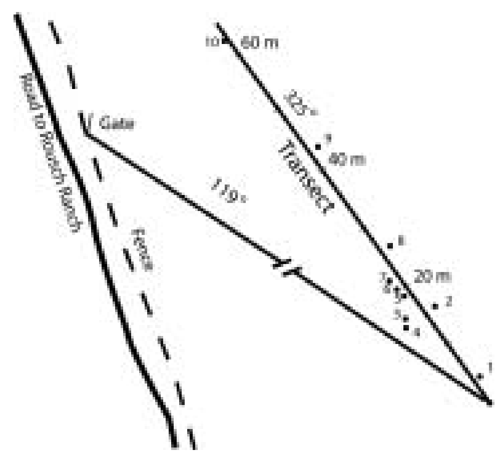
Establishment of permanent stations. Three considerations entered into the location of monitoring stations. Based on observation of moose habits, the stations were located in areas heavily used by moose. The stations were dispersed across the area in which Geyer willow occurs. The sites are accessible with relatively little effort.

Each station's location was documented in 6 ways: a) small-scale map, b) narrative description, c) large-scale sketch map, d) GPS coordinates, e) photographs of surrounding area, and f) a steel fence post. The small-scale map and narrative description should locate the station to within about a hundred meters. The large-scale sketch map, GPS coordinates, and area photographs should lead a person directly to the steel post.

Four monitoring stations were established in 2000. MS1 and MS2 are located in areas where field surveys were conducted (Sullivan Creek and Deep Creek). MS2 is located in a 30 ha fenced area from which cattle have been excluded since the mid-1980s; browsing effects at this station are unequivocally due to wildlife. MS3 and MS4 are respectively located in the French and American Creek drainages.

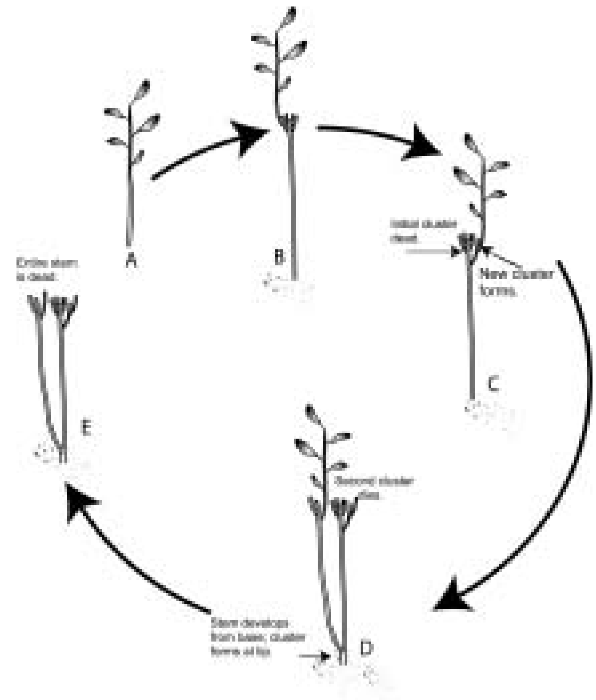
Transect for repeat photography. Two kinds of photographs were taken: a) a panoramic series, and b) a photograph down a permanent transect line. When taking the transect photo, the camera was positioned above the steel stake. The transect bearing was recorded on the sketch map. A metric tape was extended down the transect line. A metric stadia rod was included for scale; the location of the stadia rod was recorded on the sketch map.

Along the transect line, the location of 10 Geyer willow plants was documented by recording their distance along the transect line and their offset (N/S or E/W) from that line. Two heights were recorded for each plant: a) the height to the base of the tallest current-year-growth (H_{pyg}), and b) the height to the tip of the tallest stem killed by browsing (H_D).



A typical transect photograph is shown to the left. While photographs provide tangible evidence of plant condition, their interpretation is subjective. By documenting the location and measurement of 10 plants, we provide future viewers a limited quantitative perspective. The effect of browsing often is difficult to see in photographs that are taken late in the growing season when current-year-growth extends well beyond the twig clusters.

Trend assessment based on LD Index. This index measures the relationship between the height of live stems and the height of stems killed by browsing.



The method was based on the following observations. Willow shrubs with dead stems are common throughout Mt. Haggin WMA. Such shrubs are typically composed of stems of different age as represented by the types shown in sequence A-E. From establishment to death, a typical stem progresses through the following history. Stems are light-to-moderately browsed until they grow above snowcover or above other forms of mechanical protection (A).

Once the stem is available to ungulates, browsing causes clusters of twigs to form at the tip (B). After a period of time, the cluster-bearing portion of the stem dies, and one or more lateral branches develop from a lower position on the stem; these branches assume the role of terminal leader. The lateral branches might develop at the base of the original cluster (C), or may develop at the base of the original stem (D). Clusters of twigs form on the new terminal leader, and after a period, the new terminal leaders die. Finally, the entire above-ground portion of the stem dies (E).

The LD Index monitoring method is based on the difference in the height of stems killed by browsing versus the height of live stems. Where there are both live and dead stems present, there are three possible relationships:

a) Live and dead stems may be at the same height,
b) Live stems may be below the height of the dead stems, and
c) Live stems may be taller than the dead stems.

The relationships would be produced as follows. The dead clusters of twigs form a zone of mechanical protection. The young stems that develop from the base of the shrub are typically not browsed until they extend beyond the dead stems. Once live stems extend above that mechanical protection, browsing begins and a new cluster of twigs develops. Under these circumstances, the base of current-year-growth is about the same height as the dead cluster of twigs (C and D).

As browsing pressure continues and the vigor of the shrub diminishes, the base of the current-year's-growth may fall below the level of the dead stems. Alternatively, if a plant is protected from browsing, the base of current-year's-growth will progressively grow above the height of the stems killed by browsing. These height relationships form the basis of one method of assessing trend during monitoring.

Stems from 20 plants were selected for measurement based on height and vigor. To meet the height criterion, the base of current-year-growth of the tallest stem had to be within the zone 75 – 200 cm above the ground. Stems in this region are exposed to browsing. Shorter plants were sampled when necessary.

Of plants meeting the height criterion, the most vigorous were selected for measurement. The reasoning was as follows. For the full-statured community to persist, tall plants must be replaced as they die. The tall plants are relatively long-lived, so only a few young individuals must grow to full stature. For that reason, we biased sampling to include those plants that most likely would succeed. Plants were not marked for remeasurement in subsequent years; each year's sample is based on a new selection that might or might not include plants measured in previous years.

The height of the tallest stem was measured to the base of current-year-growth (H_{pyg}). Stems killed by browsing were identified by bite marks and clusters of twigs. Height was measured to the tip of the dead stem (H_D). The LD Index was calculated from: $H_{pyg} – H_D$. Values near zero indicate that browsing limits current-year-growth to the zone of mechanical protection. Negative values indicate that the community is in significant decline. Positive values indicate recovery.

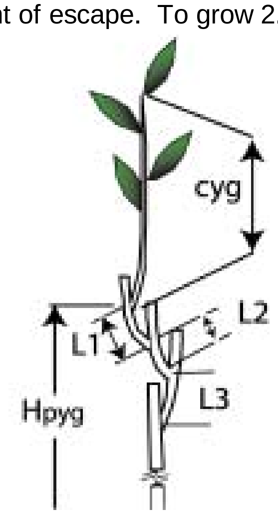
LD Index data indicate that Geyer willow is in decline at all monitoring sites; most current-year-growth that extends above the limit of mechanical protection is consumed during the winter.

Monitoring station	LD Index ± SE (cm)	Maximum value found	Minimum value found
1	-12.3 ± 5.4	29	-68
2	-38.3 ± 10.0	0	-155
3	-8.5 ± 3.5	13	-49
4	1.7 ± 5.5	58	-31

At MS1, MS2, and MS3, the mean LD Index was less zero, while the mean LD Index of 1.7 at MS4 was very close to zero. Out of the entire sample set of 80 stems, only 16 had LD Index values greater than 0, 9 of which were at MS4. The maximum LD Index value encountered was 58 cm; this stem was at MS4. The low LD Index values confirm what can be seen with the eye during the growing season. From a distance, many willow stands are brownish in color; stems with leaves are obscured by taller dead stems.

Trend assessment based on $NAGR_{L3}$. The second of the two monitoring methods is based on a relationship between lifespan and the minimum growth rate that will enable the stem to grow out of ungulate reach. Dead stems, such as those seen in the second photo on page 16, are evidence that browsing can kill. It follows that heavily browsed stems have a limited period to grow out of reach. We determined the lifespan of heavily browsed stems by taking sections of dead stems (presumed to have been killed by browsing) and counting the number of annual rings. Most sections were taken from the region labeled DB in the figure above (Type D). The average age at death was 10.2 ± 0.3 years (± SE, N=116, unpublished data).

We established a threshold $NAGR_{L3}$ value as follows. If a stem does not grow tall enough to escape browsing within about 10 years, dieback will occur. We used 2.5 m as the height of escape. To grow 2.5 m in 10 years, the stems must grow an average of 25 cm per year. Where other species are monitored at other locations, a corresponding stem lifespan and threshold growth rate would have to be determined.



The stems selected for LD Index measurement were also used for $NAGR_{L3}$ measurements. The following data were collected from each stem:

1. Cyg (length of current-year-growth). In this example, assume that the data were collected in August 2000. The current-year-growth segment would have been produced the same growing season, that is, in 2000.
2. L1 (live length of the segment produced the previous year—i.e., in 1999.
3. L2 (live length of the segment produced the previous year—i.e., in 1998)
4. L3 (live length of the segment produced the previous year—i.e., in 1997).

The growing season years were determined by inspection of terminal bud scars. If a complete annual increment died, the length for that year would be entered as zero. For example, if the segment produced in 1998 died, the 1999 segment might develop from the 1997 segment. The remains of the 1998 segment would be identifiable from terminal bud scar relationships. Because the 1998 segment did not contribute to live stem length, its value—with respect to growth rate—is zero.

Because monitoring data will be collected each year, we need to be able to distinguish between data collected in different years. A two-part nomenclature is used. The first part refers to the segment type (cyg, L1, L2, or L3); the second part, written as a subscript, refers to the year in which the data were collected. For example, $L1_{2000}$ refers to an L1 segment that was measured in 2000.

Growth that occurred during a single year can be tracked over a subsequent three-year period. For example, $L1_{2001}$, $L2_{2002}$ and $L3_{2003}$ would all be expressions of the fate of current year growth produced in 2000.

The net annual growth rate for the preceding three years ($NAGR_{L3}$) was calculated by (L1 + L2 + L3) / 3. The resulting value was compared to the threshold value of 25 cm / year.

Mean $NAGR_{L3}$ values for all four sites were well below the threshold value of 25 cm / year (Tab. 1). Of the 80 stems sampled, only 7 exceeded the threshold value; 5 of these were at MS4.

Monitoring station	$NAGR_{L3} \pm$ SE (cm / year)	Maximum value found	Minimum value found
1	11.2 ± 2.5	51.7	1.3
2	8.5 ± 1.5	28.7	1.7
3	9.9 ± 1.5	24.0	2.7
4	14.2 ± 2.4	34.3	2.0

The $NAGR_{L3}$ method of measuring growth rate is rapid and nondestructive. However, there are sources of error that should be considered. Under heavy browsing pressure, stems undergo cycles of growth and dieback. During periods of dieback, some stem segments will likely be within the protective zone of dead stems. Such stems will have larger $NAGR_{L3}$ values compared to stems where all segments were exposed to browsing. Factors unrelated to browsing may reduce growth rate. For example, current year growth values in drought years might be lower compared to values in moist years.

Browsing may inhibit height growth in three ways. First—and most obvious—consumption removes material that would otherwise have contributed to height. Second, browsing-induced stress may reduce growth potential. Third, browsing may inhibit height growth by running out the stem's biological clock. Young stems elongate rapidly when they are young, and slow down as they mature. Because intensely browsed stems undergo cycles of dieback, a 1-m-tall stem might be10-20 years old at the base. On such stems, we have observed that current-year-growth is sometimes only a few cm in length. Such stems might have entered into an age-related phase of reduced growth.

Summary of trend.

The surveys and monitoring conducted at Mt. Haggin WMA in 2000 indicate that Geyer willow is in decline. During the field surveys, no individuals exposed to browsing were found to have uninterrupted-growth- or released-type architectures. During monitoring, we sampled the most vigorous plants. LD Index data indicate that current-year-growth is browsed back to the level of mechanical protection. The preponderance of negative LD Index values indicates that major dieback has already occurred. The site-wide average $NAGR_{L3}$ values are well below the threshold value of 25 cm / year.

The quantity of available browse will diminish as dieback progresses. If the moose population remains approximately constant, increased pressure will be placed on the remaining browse plants. All lines of evidence indicate that, if present trends continue, the willow community will likely be converted to a meadow. To reduce browsing pressure, the moose harvest quota was increased by 50% for the 2000 hunting season. During the winter of 2000/2001, snowdepth was markedly less compared to typical years. The reduced snowpack allowed moose to disperse over a broader area compared to years in which snow is uniformly deeper. These factors are expected to influence willow growth. To document that response, we will conduct surveys and monitoring on an annual basis.

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Permanent Browse Monitoring Stations at Mt Haggin Wildlife Management Area

Richard B. Keigley, Craig Fager and Kriss Douglass

Date

The program was initiated September 28 and 29, 2000.

Objective

Establish monitoring program that will provide data that can be applied to determining trend in browse condition.

Methods

Craig Fager selected four sites. Each site was marked by a steel fence post. The location of the post was identified both by narrative and by GPS. Photographs were taken and sketch maps were drawn to assist other individuals in locating the posts. The bearings drawn on the maps are true magnetic north.

A transect line was defined by bearing. The purpose of the transect was to provide a means of taking repeat photographs. Photographs were taken. A stadia rod was included for scale. Flagging was tied on the rod at 2 m-intervals. The location of the stadia rod along the transect is described in the sketch map.

In 2000, Geyer willow (*Salix geyerianna*) was measured. The location of 10 plants was documented along the transect line by position along the transect and offset (E/W or N/S). Measurements are in meters. H_{pyg}, and H_d were measured for the tallest stem as measured to H_{pyg} (i.e., not cyg). We anticipate that the remeasurement of these plants will occur at intervals of several years. For a given monitoring station, the above steps can be accomplished within a period of about 2 hours.

$NAGR_{L3}$ was measured on 20 plants. (For a description of the $NAGR_{L3}$ method, see the Steel Creek report. The locations of the $NAGR_{L3}$ plants were not documented; given plants are not remeasured in the course of future monitoring. For a given station, $NAGR_{L3}$ measurements can be accomplished within a period of about one-half hour.

Summary of 2000 data

Monitoring Station	$NAGR_{L3} \pm$ SE	$(H_{pyg} – H_d) \pm$ SE
1	10.9 ± 2.7 cm	11.0 ± 2.7 cm
2	8.9 ± 1.6 cm	8.8 ± 2.0 cm
3	10.3 ± 1.5 cm	10.5 ± 1.9 cm
4	13.4 ± 2.4 cm	14.0 ± 3.0 cm

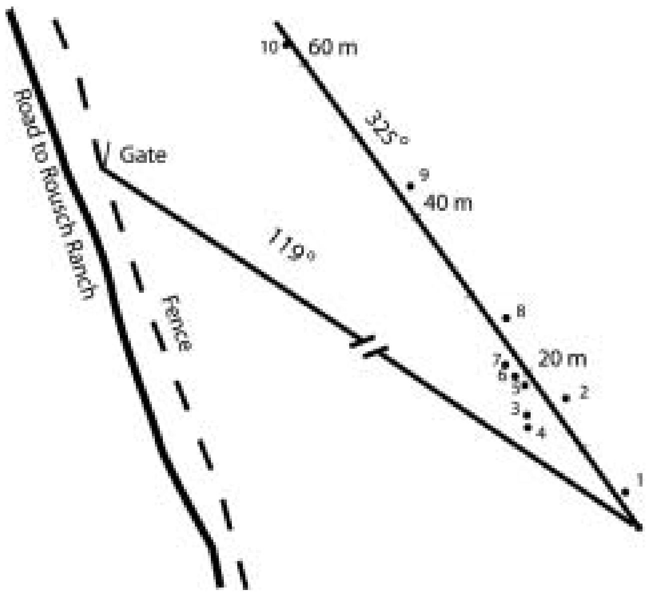
Monitoring Station 1

This station is in the Sullivan Creek drainage, accessed by road to Rausch Ranch. Drive 1.15 mile from second gate (the one that is secured by only a chain). Park at gate in fence; there is a telephone junction box to the southwest of the road.

From the gate to the station post follow a bearing of 119° about 100m. The photograph to the right shows the view from the gate. The station post can be seen in the photograph.

The GPS location of the station post is:
45° 57.22N 113° 6.42W.

The sketch map below indicates the location and bearing of the transect line, and the location of 10 plants that are described in the adjacent table. Tic marks on the transect are drawn at 10m intervals along the transect line. The small numbers adjacent to dots refer to the 10 plants.



Obs	Trnsct Pt	Offset	H_{pyg}	H_d
1	2.3	1.5 E	135	164
2	15.0	2.5 E	165	200
3	16.0	4.0 W	140	132
4	14.2	5.0 W	114	122
5	18.9	2.0 W	79	80
6	19.1	2.0 W	207	160
7	21.3	2.0 W	360	250
8	27.6	2.2 E	60	47
9	43.9	1.9 E	89	92
10	62.7	0.5 W	97	127

The table above describes the location and height of 10 plants. Heights are in meters.

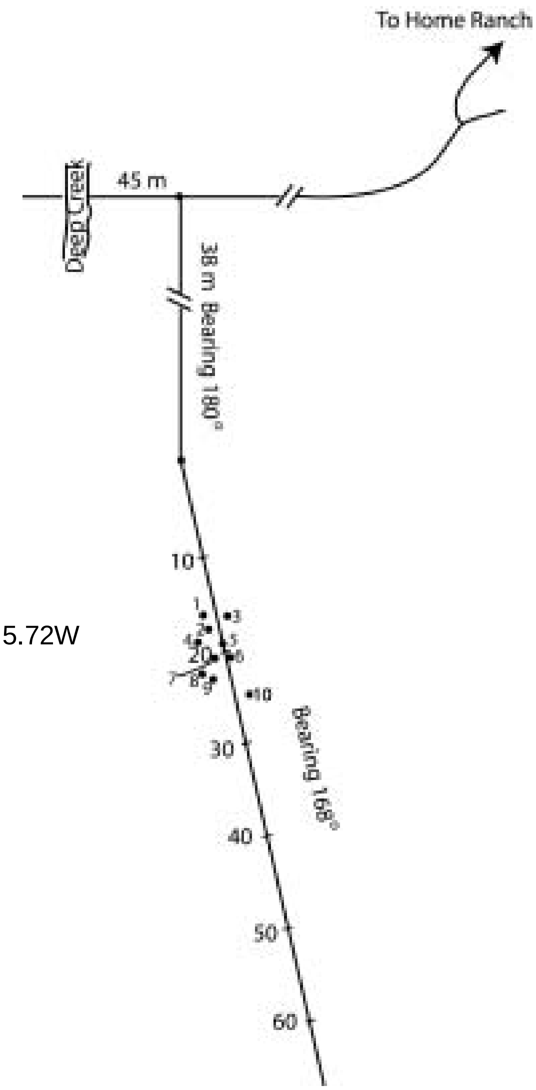
Photograph down transect of monitoring station 1. Data collected in 2000 are described below.

Monitoring station 1: 28SEP00			2000	1999	1998	1997		
OBS	Hpyg	HD	LCYG	L1	L2	L3	NAGR	Hpyg-Hd
1	120	140	2	37	11	1	16.3	-20.0
2	144	130	4	19	19	6	14.7	14.0
3	88	88	1	6	38	21	21.7	0.0
4	57	57	17	2	24	12	12.7	0.0
5	74	80	3	1	1	2	1.3	-6.0
6	114	120	19	10	4	1	5.0	-6.0
7	183	180	24	55	68	32	51.7	3.0
8	90	146	13	8	3	2	4.3	-56.0
9	120	150	7	4	3	1	2.7	-30.0
10	130	158	7	4	1	3	2.7	-28.0
11	71	71	10	6	2	4	4.0	0.0
12	70	70	18	27	10	30	22.3	0.0
13	94	94	2	2	3	4	3.0	0.0
14	77	77	8	5	4	22	10.3	0.0
15	107	78	10	3	16	13	10.7	29.0
16	115	120	13	3	2	2	2.3	-5.0
17	96	130	5	17	18	2	12.3	-34.0
18	113	156	2	5	7	7	6.3	-43.0
19	142	210	14	24	3	5	10.7	-68.0
20	164	160	6	2	22	3	9.0	4.0
Average:	108.5	120.8	9.3	12.0	13.0	8.7	11.2	-12.3
Stan Err:	7.4	9.5	1.5	3.2	3.7	2.2	2.5	5.4

Monitoring Station 2

Station 2 is located inside an 80-acre fenced area from which livestock have been largely excluded since 1984.

To access the site, drive down road at wildlife viewing sign, take left just before the cattle guard; drive to within 45 meters from where the bridge was washed out by Deep Creek. The photograph below was taken from the road approximately down a bearing of 180°, and shows the path one would take to the monitoring station post.



Coordinates of the monitoring station post: 45° 56.26N 113° 5.72W

Obs	Trnsct Pt	Offset	H_{pyg}	H_d
1	17.2	0.7 W	0.62	0.62
2	18.6	0.3 W	0.90	0.90
3	18.2	2.4 E	2.68	2.68
4	18.8	1.8 W	0.67	0.91
5	19.6	0	0.67	0.79
6	21.4	0.9 E	1.13	1.06
7	19.9	1.2 W	1.02	1.14
8	21.3	3.4 W	0.54	0.54
9	21.3	1.6 W	1.18	1.18
10	25.0	1.8 E	1.09	2.50

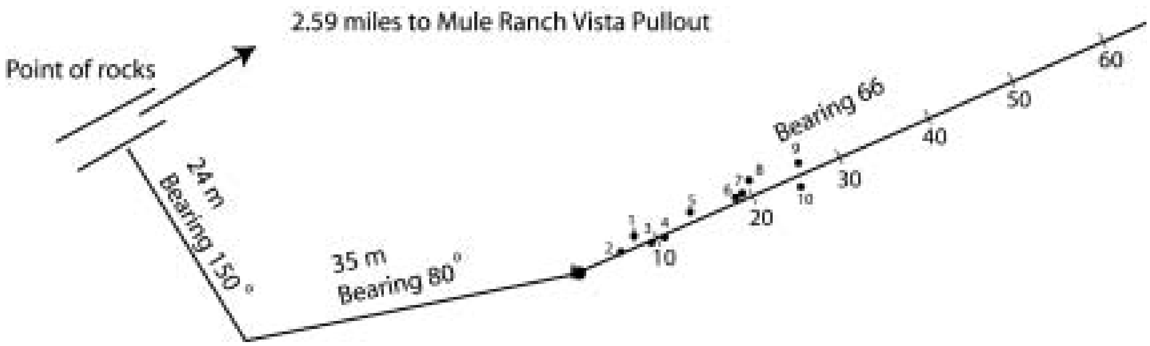
The table above describes the location and height of 10 plants. Heights are in meters.

The photograph below was taken along the transect, down a bearing of 168°. Flags are tied to the stadia rod at 2 m intervals.

Monitoring station 2: 28SEP00			2000	1999	1998	1997		
OBS	Hpyg	HD	LCYG	L1	L2	L3	NAGR	Hpyg-Hd
1	60	60	10	1	3	1	1.7	0.0
2	97	97	1	10	2	2	4.7	0.0
3	85	100	10	9	2	16	9.0	-15.0
4	81	87	6	5	1	1	2.3	-6.0
5	100	100	4	4	13	21	12.7	0.0
6	69	95	11	6	20	11	12.3	-26.0
7	135	165	16	10	2	5	5.7	-30.0
8	198	198	25	19	17	1	12.3	0.0
9	82	110	10	10	10	1	7.0	-28.0
10	98	110	6	5	5	12	7.3	-12.0
11	167	167	7	13	3	2	6.0	0.0
12	125	230	10	2	4	8	4.7	-105.0
13	72	150	3	3	7	5	5.0	-78.0
14	97	97	16	12	1	2	5.0	0.0
15	115	185	14	13	3	7	7.7	-70.0
16	114	204	4	5	3	4	4.0	-90.0
17	95	250	7	20	40	11	23.7	-155.0
18	140	228	8	7	26	53	28.7	-88.0
19	92	140	5	18	6	2	8.7	-48.0
20	75	90	20	1	3	2	2.0	-15.0
Average:	104.9	143.2	9.7	8.7	8.6	8.4	8.5	-38.3
Stan Err:	7.7	12.7	1.4	1.3	2.3	2.7	1.5	10.0
						MAX	28.7	0.0
						MIN	1.7	-155.0

Monitoring Station 3

Monitoring station 3 is located in the French Creek drainage approximately one mile SW of the Moose Creek confluence and 2.59 miles SW of the Mule Ranch pullout. The rock outcrop adjacent to the pullout is a distinctive landmark.



The coordinates at the stake are:
45° 58.86 N / 113° 3.06 W

Obs	Trnsct Pt	Offset	H_{pyg}	H_d
1	8.6	1.9 N	0.69	0.61
2	6.6	0	0.35	0.41
3	9.1	0.2 S	0.36	0
4	10.8	0.9 S	0.53	0.47
5	14.0	1.7 N	0.35	0.55
6	18.7	0.7 N	0.88	0.83
7	19.8	0.9 N	0.89	0.82
8	20.3	2.6 N	0.91	1.11
9	26.7	1.6 W	4.27	1.41
10	25.8	2.4 E	1.40	1.58

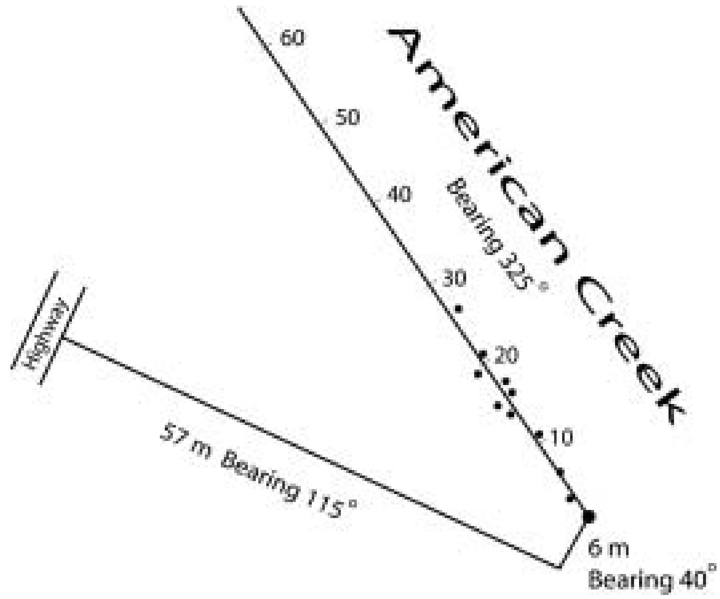
The table above describes the location and height of 10 plants. Heights are in meters.

Monitoring station 3:	28SEP00		2000	1999	1998	1997		
OBS	Hpyg	HD	LCYG	L1	L2	L3	NAGR	Hpyg-Hd
1	116	126	4	5	3	1	3.0	-10.0
2	93	80	10	25	15	11	17.0	13.0
3	78	78	3	1	3	7	3.7	0.0
4	87	90	5	2	24	32	19.3	-3.0
5	66	66	9	2	1	9	4.0	0.0
6	84	104	14	6	11	5	7.3	-20.0
7	93	86	28	10	13	2	8.3	7.0
8	85	98	12	14	2	11	9.0	-13.0
9	101	101	10	7	7	9	7.7	0.0
10	113	125	12	23	1	3	9.0	-12.0
11	80	107	4	2	2	5	3.0	-27.0
12	77	117	5	11	27	19	19.0	-40.0
13	123	130	3	4	8	12	8.0	-7.0
14	145	194	8	11	34	13	19.3	-49.0
15	102	115	11	14	5	3	7.3	-13.0
16	87	94	7	5	2	1	2.7	-7.0
17	146	142	20	19	7	3	9.7	4.0
18	89	78	12	14	30	28	24.0	11.0
19	105	108	6	3	2	4	3.0	-3.0
20	98	98	3	6	27	8	13.7	0.0
Average:	98.4	106.9	9.3	9.2	11.2	9.3	9.9	-8.5
Stan Err:	4.8	6.4	1.4	1.6	2.5	1.9	1.5	3.5

Monitoring Station 4

Monitoring Station 4 is located in the American Creek drainage.

The coordinates of the station post are:
45° 58.53 N / 113° 1.43 W.



Obs	Trnsct Pt	Offset	H_{pyg}	H_d
1	3.2	0.8 W	1.76	1.91
2	6.4	0	1.08	1.83
3	10.6	0.6 E	1.61	2.26
4	13.0	1.1 W	1.94	1.50
5	14.5	1.3 W	1.45	1.69
6	15.6	0.5 E	1.05	1.32
7	17.4	0.6 E	1.02	1.80
8	19.3	1.3 N	1.90	1.67
9	20.2	0.3 E	1.06	0.99
10	27.2	1.4 N	1.55	1.68

The table above describes the location and height of 10 plants. Heights are in meters.

Monitoring station 4: 28SEP00			2000	1999	1998	1997		
OBS	Hpyg	HD	LCYG	L1	L2	L3	NAGR	Hpyg-Hd
1	131	96	51	50	39	3	30.7	35.0
2	91	122	16	16	5	19	13.3	-31.0
3	122	107	10	18	16	18	17.3	15.0
4	110	133	10	9	9	3	7.0	-23.0
5	110	105	15	15	15	3	11.0	5.0
6	111	142	19	17	37	27	27.0	-31.0
7	130	137	8	2	9	2	4.3	-7.0
8	166	126	33	25	19	5	16.3	40.0
9	123	109	22	7	43	44	31.3	14.0
10	110	109	39	7	6	5	6.0	1.0
11	79	100	19	3	2	1	2.0	-21.0
12	130	145	27	8	4	3	5.0	-15.0
13	109	140	5	6	13	5	8.0	-31.0
14	109	97	22	6	46	41	31.0	12.0
15	143	85	10	14	47	42	34.3	58.0
16	160	146	6	10	10	13	11.0	14.0
17	130	130	17	1	6	7	4.7	0.0
18	107	117	4	2	3	2	2.3	-10.0
19	130	115	32	29	3	6	12.7	15.0
20	118	125	14	21	3	3	9.0	-7.0
Average:	121.0	119.3	19.0	13.3	16.8	12.6	14.2	1.7
Stan Err:	4.6	4.0	2.8	2.6	3.6	3.2	2.4	5.5

Effect of Browsing on Willow in the Steel Creek Grazing Allotment
Wisdom District Beaverhead / Deerlodge National Forest

Richard B. Keigley and Gil Gale
December 2000

Introduction

The Steel Creek drainage serves as both wildlife range (primarily moose and elk) and as a livestock grazing allotment. For some years there has been concern about the effect of browsing on willows. Dense clusters of twigs have formed at the end of branches; entire stems of some plants have died. As of 1996, the relative impacts attributable to each of the ungulate species had not been documented.

In 1997 a study was begun to determine: a) the current level of browsing, b) the history of past browsing pressure, and c) the relative roles of the different ungulate species. All areas surveyed in 1997 were found to be 100% intensely browsed as measured by the methods described in Keigley and Frisina (1998). A reconstructed history of aspen browsing indicated that browsing pressure increased sometime in the mid-1980s (Keigley and Frisina 1998: pp. 122-124). The intense aspen browsing occurred east of the Steel Creek Ranger Station in an area in which all livestock have been excluded for several years, thus indicating that wildlife were responsible. While the 1997 study indicated that wildlife had a significant impact on browse condition, no data were collected that documented the potential impact of livestock within grazed areas, or the combined impact of livestock and wildlife.

In 1998 we began a study of browsing impacts in the Steel Creek grazing allotment. The objectives of the study were to:

1. Determine willow growth potential,
2. Document the effect of browsing,
3. Document the response of willows to protection from browsing,
4. Determine the amount consumed each year,
5. Distinguish between the impacts of livestock and wildlife, and
6. Evaluate the consistency of the measurement methods.

View upstream from the study area. *Salix geyerriana* is the dominant willow species. *Salix drummondiana* and *S. Boothii* are less common; older individuals of both species grow to about 2-m tall. *Salix bebbiana* is much less common, and where present, is browsed close to ground level. The carcass of an old Bebb willow that had attained typical stature is located near the study area. Beaver are absent. The remains of relic beaver dams indicate that beaver were once an important hydrologic influence.

Methods

In the spring of 1998 a pair of exclosures was constructed at the southern end of the Steel Creek grazing allotment. An 8-foot-tall exclosure, constructed of poles, was designed to exclude all ungulates. A 4-foot-tall exclosure, constructed of wire, was designed to exclude only livestock. The wire can be lowered to ground level when livestock are absent, making the exclosure even more accessible to wildlife during the winter.

The 8-foot-tall fence can be seen in the right-center of the photograph. The 4-foot-tall livestock exclosure fence is out of view; it is located in the left-central area of the photograph.

> The area within the 8-ft-tall fence is abbreviated below to: L/W-exclosure (or exclosed).
>
> The area within the 4-ft-tall fence is abbreviated: L-exclosure.
>
> The area open to browsing by all ungulates is abbreviated: No-exclosure.

View from inside the livestock exclosure.

Two approaches were used to measure the response to treatment:

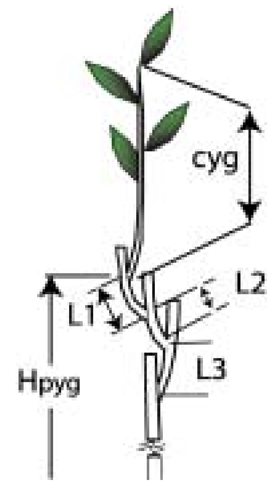
1) Net annual growth rate (NAGR; see Keigley and Frisina 1998: p. 109), and
2) Growth above the height of stems killed by browsing.

1) NAGR. Browsing can greatly reduce or halt height growth. Because stems have a finite lifespan (a lifespan that is shortened by intense browsing), there is a minimum growth rate that will enable plants to attain typical stature before they die. That minimum rate can be estimated based on: a) the lifespan of heavily browsed stems, and b) the NAGR of stems that successfully attained typical stature. A comparison of NAGR between treatments provides an indication of treatment effect.

2) Growth above the height of stems killed by browsing. Under conditions of intense browsing, stem height growth is often limited to the height of mechanical protection afforded by stems killed by browsing. If browsing level is reduced, stems may grow above that height. A comparison of the height of live stems versus the height of stems killed by browsing provides an index of willow trend.

The sample design was as follows. From each treatment, 20 plants ranging 50 – 150 cm tall were randomly selected for measurement. (Plants below 50 cm tall may be protected from browsing by snowcover; plants taller than 150 cm may be above the height typically browsed by some ungulates, such as livestock.) From each plant, I took data from the tallest stem, with stem-height measured to the base of current-year-growth (H_{pyg}). Stems were not marked for re-measurement in subsequent years.

The following data were collected from each stem:



1. H_{pyg} (height to the base of current-year-growth)

2. H_D (tallest height to point where a complete annual segment was killed by browsing)

3. Cyg (length of current-year-growth). In this example, assume that the data were collected in August 2000. The current-year-growth segment would have been produced the same growing season, that is, in 2000.

4. L1 (live length of the segment produced the previous year, i.e., in 1999)

5. L2 (live length of the segment produced the previous year—i.e., in 1998)

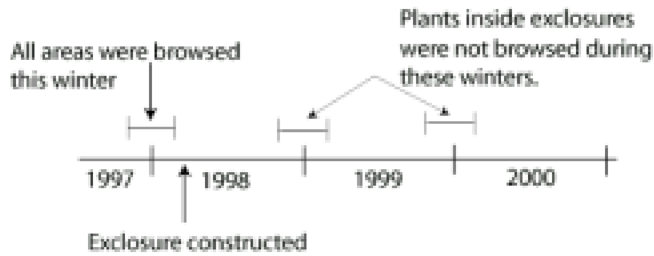
6. L3 (live length of the segment produced the previous year—i.e., in 1997)

To distinguish data collected in different years, the following two-part nomenclature is used. The first part refers to the segment type (cyg, L1, L2, or L3); the second part, written as a subscript, refers to the year in which the data were collected. For example, $L1_{1999}$ refers to an L1 segment that was measured in 1999.

Growth that occurred during a single year can be tracked over a four-year period. For example, $L1_{1998}$, $L2_{1999}$ and $L3_{2000}$ are all expressions of the fate of current year growth produced in 1997. To clarify why these labels refer to the same data, consider the following scenario. In 1997, a person marks a terminal leader with a wire, enabling them to track its fate over the coming years. On a data sheet, they would label the length of that segment as cyg_{1997}. The next year (in August 1998), when they locate the wire-marked segment, the length of the segment would be labeled $L1_{1998}$; a terminal leader (cyg_{1998}) would be attached to $L1_{1998}$. When the data collection is repeated in 1999, the wire-marked segment would be labeled $L2_{1999}$; in 2000, the wire-marked segment would be labeled $L3_{2000}$. When reviewing the 1998-2000 dataset for that stem, $L1_{1998}$, $L2_{1999}$ and $L3_{2000}$ would all refer to the same identical wire-marked piece that first elongated in 1997. If measurements were accurate, the values for $L1_{1998}$, $L2_{1999}$ and $L3_{2000}$ should be identical.

In the Steel Creek drainage, browsing by moose is highest during periods of snowcover. The diagram below describes some relationships between treatment and data. There were two opportunities to measure the effect of browsing on plants that were subsequently protected from browsing. $L2_{1999}$ would have been current-year-growth in 1997. Because ungulates typically browse current-year-growth and because plants were not protected from browsing during the

1997/1998 winter, $L2_{1999}$ did not experience the treatment effects of exclosure. Similarly, $L3_{2000}$ did not experience exclosure effects.



Results

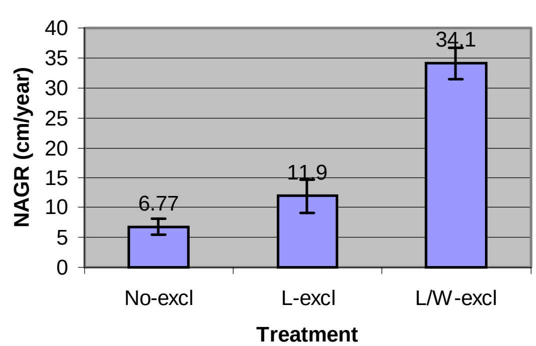
Table 1. Summary of results. N = 20 for all data sets except L-exclosed 2000 where N = 19 and $L3_{2000}$ from the L/W-exclosure where N = 18. In the case of L-exclosed, an error was made in setting up the data collection form (the heading was enumerated sample number 1). In the L/W-exclosure 2000 dataset, there were four cases in which L3 segments were not present because the L2 segment was the oldest stem segment (i.e., L2 emerged from the ground).

Treatment	Year msrd.	Cyg	L1	L2	L3
No exclosure	1999	25.6 ± 2.2	11.1 ± 2.5	4.9 ± 1.5	4.5 ± 1.2
	2000	30.8 ± 2.7	5.7 ± 1.1	7.9 ± 2.1	5.6 ± 1.0
Livestock Exclosed	1999	Nd	Nd	Nd	Nd
	2000	30.3 ± 2.6	8.1 ± 1.4	15.7± 5.3	9.8 ± 3.0
Livestock / wildlife exclosed	1999	18.0 ± 1.5	38.9 ± 4.0	11.3 ± 2.5	9.5 ± 2.5
	2000	16.1 ± 1.6	18.6 ± 3.2	49.7 ± 5.1	15.8 ± 2.4

1. Growth potential. An evaluation of the effect of browsing must be placed in the context of how willows at the site c*ould* grow in the absence of browsing. For example, if a trend to drier conditions limited height growth, it would be erroneous to attribute a lack of height growth to browsing alone, even if plants were intensely browsed. Over a period of years, willow growth inside the exclosure will indicate the site potential for the study area. In the meantime, we can get a sense of the site's potential from two aspects: 1) the height attained in the past, and 2) the short-term response of willows that are protected from browsing.

Older Geyer willow plants in the study area attained heights greater than 2.5 m. Intense browsing currently prevents young plants from attaining that stature. Growth to more than 2.5 m may indicate the site's current growth potential. However, there is the possibility that hydrologic conditions may have changed since those older willow plants were established. The presence of abandoned beaver dams indicates that beaver were once an important influence. The absence of beaver may cause drier conditions and a reduced growth potential. The growth of young plants within the exclosure will provide an indication of growth potential under current conditions.

The short-term response of willow stems provides another indication of growth potential. Those data are discussed in item 3 below.



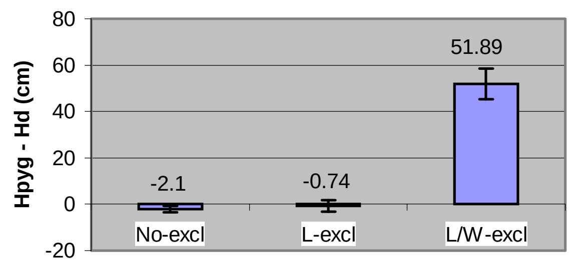
2. The effect of browsing.

Summary:

a. NAGR < 12,
b. Height growth has stopped.

NAGR. The NAGR of plants exposed to browsing was significantly lower than that of plants that were protected from browsing (ANOVA, Post-hoc Bonferroni test: $P = 0.00$). Because the L_3 segments of plants within the L/W exclosure were exposed to browsing during the 1997/1998 winter, the NAGR of those plants can be expected increase when the 2001 measurements are taken. A study of Geyer willow at Mt. Haggin WMA indicates that, at that site, stems must have an NAGR of about 20-25 cm/year if they are to grow through browse zone. The NAGR of browsed stems at Steel Creek is significantly less than this amount.

Growth above the height of stems killed by browsing. When intense browsing occurs, stem growth is typically limited to a height determined by mechanical protection; H_{pyg} and H_d are approximately equal; an index calculated by subtracting H_d from H_{pyg} would be approximately zero. As shown in the graph on the previous page, this was the case of browsed plants at Steel Creek. The index value of 51.9 indicates that stems of plants within the L/W exclosure are growing above the limit of mechanical protection.



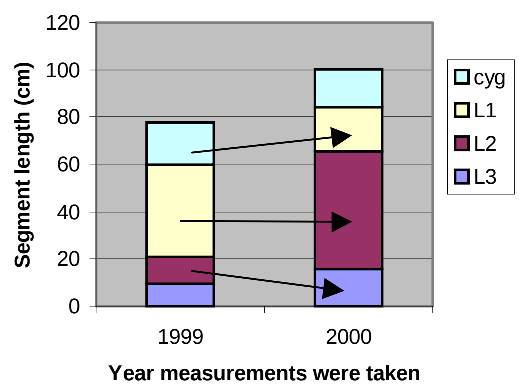
3. The response of willows to protection from browsing.

Summary:

a) NAGR significantly greater than that of browsed plants.
b) Stems are growing beyond the limit of mechanical protection.
c) Current-year-growth declined.

The arrows on the graph to the right show the relationship between segments measured in 1999 to those measured in 2000. For example, cyg_{1999} "became" $L1_{2000}$.

$L2_{1999}$, $L3_{1999}$, and $L3_{2000}$ are relatively small because those segments experienced a winter of browsing before the exclosure was constructed. In spite of the inclusion of one heavily browsed segment, the NAGR measured in 2000 (34.1 cm/year) was significantly greater than that of the browsed plants.



The $H_{pyg}–H_d$ index for plants inside the L/W exclosure was also significantly greater than that of browsed plants (Kruskal-Wallis $P = 0.00$). The index indicates that, after two years of protection, plants within the exclosure are increasing in stature above the height of mechanical protection.

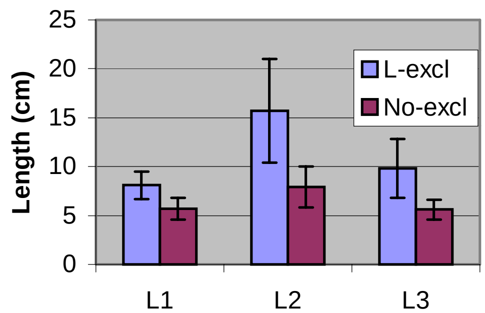
Protection from browsing caused a reduction in the length of current year growth in the next growing season. From the length of the $L1_{1999}$ segment (38.9 cm), we know the approximate length of current-year-growth in 1998. This value is consistent with the current-year-growth values measured on browsed plants in 1999 and 2000. In 1999 and 2000, the current year growth of the protected plants was slightly more than half that of browsed plants. Apparently browsing stimulates the production of current-year-growth. As a result of the decline in current-year-growth, the segment added after the second year of protection ($L1_{2000}$) was significantly less than the segment added the first year ($L1_{1999}$).

4. The amount consumed each year. Consumption was determined using the cyg_{1999} and $L1_{2000}$ data at the no-exclosure site. Current-year-growth averaged 25.6 cm in 1999. After a winter of browsing, an average of 5.7 cm live stem remained (this was measured as $L1_{2000}$). A short (typically 2-3 cm) stub of dead L1 stem extended above where current-year-growth emerged. An average of 19.9 cm was consumed or killed as a result of browsing, indicating a consumption rate of 78% over the 1999/2000 winter. Taking the dead stub into account, actual consumption would be slightly less. Consumption could not be calculated for the Livestock exclosure site since no 1999 data are available.

If one assumes that current-year-growth is similar each year, the consistency of consumption may be evaluated for years in which no current-year-growth data were taken. At the no-exclosure site, the mean current-year-growth for 1999 and 2000 was 28.2 cm. If that value is taken to be representative, the following consumption rates result:

1996 / 1997: 84% (based on $L3_{1999}$),
1997 / 1998: 80% (based on $L3_{2000}$),
1998 / 1999: 72% (based on $L2_{2000}$),
1999 / 2000: 78% (based on the data above).

5. Distinguishing between the impacts of livestock and wildlife. If one assumes that the growth potential of the two browsed sites are equal, we can compare utilization by comparing the length of the segments measured in 2000 (e.g.$L1_{L\text{-}excls}$ with $L1_{no\text{-}excl}$). If utilization is similar, the length of the segments should be equal.



As shown in the graph to the right, segments from the Livestock-exclosed site were consistently larger than corresponding segments from the site browsed by all ungulates. If the differences were real (i.e., not an artifact of sample variation), livestock browsing could be a contributing factor. In fact, the differences were not statistically significant. But the consistency of the pattern suggests that we should look more closely at factors that might produce such a relationship.

The pattern could be produced by:

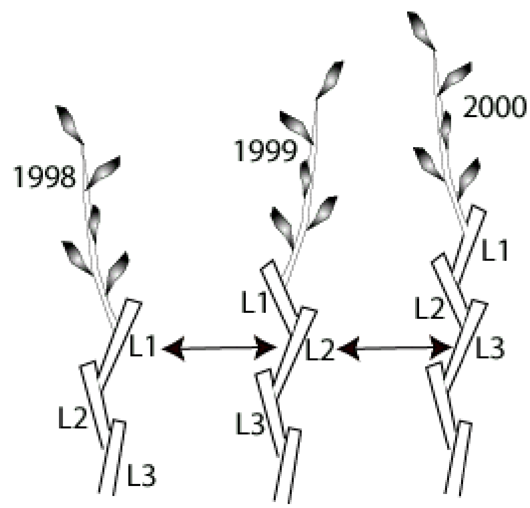
a. Higher growth potential at Livestock exclosure site. Cyg_{2000} data do not support this. This possibility can be assessed with Cyg data from 2001 and later years.
b. Reduced wildlife browsing within the Livestock exclosure due to increased snowcover. The effect of between-treatment differences in snowcover is not known at this time.
c. A significant livestock effect.

If livestock browsing is a factor, how important might it be? We can make a preliminary estimate if we assume that growth potential between sites is identical. Based on that assumption, we calculated the consumption for the past three years at both sites, and calculated the contribution of wildlife by dividing consumption in the Livestock exclosure by consumption in the area open to all browsing. An initial estimate: wildlife may account for about 77% of the browsing. It should be emphasized: 1) The differences in segment length described above were not statistically significant and may be due to chance; it is the consistent pattern that suggests we may ultimately find that a difference exists. 2) None of the factors (growth potential, exposure, livestock browsing) listed above has been eliminated.

6. Evaluation of the consistency and validity of the measurement method. I addressed two questions:

1. Are the measurements repeatable?
2. Are the measurements influenced by environmental differences that vary between sites?

Are the measurements repeatable? In a given year, data are taken that describe the remainder—after consumption—of the segments produced in each of the previous three years (e.g, for measurements taken in 2000, L1 was cyg in 1999, L2 in 1998, and L3 in 1997). When measurements are made in consecutive years, measurement repeatability can be evaluated by comparing the length of a given year's annual segment with the length of the same year's segment measured the following year. The drawing to right shows some possible relationships based on a three year period. In the case of the data collected so far, we can test repeatability by comparing $L1_{1999)}$ with $L2_{2000)}$, and $L2_{1999}$ with $L3_{2000}$. The comparison was by ANOVA following a Levene test for homogeneity of variance.



No exclosure:

$L1_{1999} = L2_{2000}$, (11.1 ± 2.5 = 7.9 ± 2.1) (P=0.34; Levene statistic 0.752)).

$L2_{1999} = L3_{2000}$, or compare 4.9 ± 1.5 to 5.6 ± 1.0 (P=0.68; Levene statistic 0.830).

Livestock / Wildlife exclosed:

$L1_{1999} = L2_{2000}$, or compare 38.9 ± 4.0 to 49.7 ± 5.1 (P=0.10; Levene statistic: 0.235).

$L2_{1999} = L3_{2000}$, or compare 11.3 ± 2.5 to 14.0 ± 2.8 (P=0.47; Levene statistic 0.397).

Variance was homogeneous for all groups. At P=0.05 there was no significant difference between means; the measurements made in 1999 were consistent with measurements made in 2000. The comparison of $L1_{1999}$ and $L2_{2000}$ within the Livestock / Wildlife exclosure came closest to being inconsistent.

Are the measurements influenced by environmental differences that vary between sites? Two kinds of environmental differences might confound evaluation of the treatment effect (i.e., browsing). Those differences are:

1. Between-site differences in growth potential, and
2. Between-site differences in exposure to browsing.

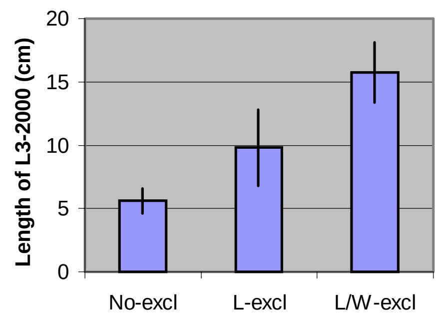
Differences in growth potential. The length of current-year-growth is one indication of environmental effect. However, clipping (such as browsing) in one year has been demonstrated to affect leader length the following year. For this reason, an evaluation of environmental influences based on current-year-growth is most valid between the Livestock exclosure site and the Livestock / Wildlife exclosure site. The comparison assumes that the between-site levels of browsing are similar. Because no 1999 data are available for the Livestock exclosure site, only 2000 data can be compared.

Hypothesis tested: $cyg_{\text{Livestock Exclosure}} = cyg_{\text{Not Exclosed}}$, or $30.3 \pm 2.6 = 30.8 \pm 2.69$. ANOVA indicated that the means were drawn from the same population at P = 0.908. A Levene test statistic of 0.577 indicated homogeneity of variance.

The similarity of current-year-growth at the Not-exclosed and Livestock-exclosure sites suggests that both sites have similar environments. Because the Livestock-exclosure site is immediately adjacent to the Livestock / Wildlife exclosure site, there is reason to believe that all sites experience a similar environment with respect to growth potential.

Exposure to browsing. The $L3_{2000}$ segment represents growth and browsing that occurred prior to construction of the exclosures. If growth potential and exposure to browsing is similar at all sites, then:

a) $L3_{2000}$ should be similar at all three sites,
b) $L2_{1999\text{-no excl}} = L2_{1999\text{-L/W excl}}$, and
c) $L3_{1999\text{-no excl}} = L3_{1999\text{-L/W excl}}$.



NOTE: $L3_{2000}$ and $L2_{1999}$ were current-year-growth in 1997 and were exposed to browsing during the winter of 1997/1998.

Case a: $L3_{2000}$ for all three sites was tested by Kruskal Wallis (variance was heterogeneous after $\log_{10}$ transformation) and found to be different (P=0.002). A median test suggests that the Not- and L-exclosed sites are similar to one another and distinct from the L-W-exclosed site.

Case b: Comparison of $L2_{1999}$ at L/W- and Not-excl sites was by ANOVA. The mean length of the L/W-exclosed L2 segments was found to be significantly greater than that of the Not-exclosed plants (P=0.032). If growth potential is similar, this suggests decreased exposure to browsing within the L/W-exclosure area.

Case c: Comparison of $L3_{1999}$ at L/W- and Not-excl sites was by ANOVA. No significant difference (at P<0.05) was found, however the fact that P=0.084 suggests that a real difference may exist.

What does this mean with respect to livestock versus wildlife use? The similarity of current-year-growth length in the L- and Not-exclosed sites indicates that both sites have similar growth potential. Given similar growth potential, the slightly greater NAGR of L-exclosed willows suggests that livestock may have an effect. But, as described above, the comparison of segment lengths suggests (but does not statistically document) that the L-exclosed site is less exposed to browsing. If the L-exclosed site is found to be less exposed to browsing, then the differences in NAGR may be due to this effect rather than due to the influence of livestock. This situation can be clarified in 2001 by sampling outside the perimeter of the L-exclosed fence.

Literature Cited

Keigley, R.B. and M.R. Frisina. 1998. Browse evaluation by analysis of growth form. Montana Fish, Wildlife & Parks. Helena, MT. 149 pp.

Browse Condition at Red Rock Lakes National Wildlife Refuge

Richard B. Keigley and Michael R. Frisina

The condition of willow was examined at two sites located west of the refuge headquarters: the Old Garbage Dump and Odell Creek. The two sites are in close proximity. The Old Garbage Dump site was located in a pasture occupied by livestock in 1998. Livestock had not been present at the Odell Creek site. The measurements were taken September 10, 1998.

Current year growth was classified into five categories:

- Class 1: 0 - 5% of the leaders were browsed,
- Class 2: 6 - 25%
- Class 3: 26 - 50%
- Class 4: 51 - 75%, and
- Class 5: 76 - 100% of the leaders were browsed.

At each site, 20 willows were examined that ranged in size from about 40 - 150 cm. Willows in this size category are indicators as to whether or not browsing will permit young willows to grow to typical stature.

At the Old Garbage Dump site, all of the willows had arrested-type architecture (Keigley and Frisina 1998); none had uninterrupted growth type architecture. At the Odell Creek site, 16 willows had arrested-type architecture, 3 had retrogressed-type architecture, and 1 had uninterrupted-growth type architecture. The impact of ungulates (cattle and potentially moose) at the Old Garbage Dump and Odell Creek sites is notable. The average height of the arrested-type willows was 54 $\pm$ 0.8 cm ($\pm$ SE) at the Old Garbage Dump site and 67 $\pm$ 0.8 cm at the Odell Creek site. The table on the following page presents the data collected on September 10, 1998. The photographs on page 4 were also taken on September 10, 1998.

Willows at both sites are heavily browsed as indicated by architectures. The growth of older willows (see photographs) to typical stature indicates that there has been an increase in browsing pressure and that the browse resource is in decline. The data collected on September 10, 1998 show that, during the 1998 growing season, heavy browsing occurred at the Old Garbage Dump site, while very little browsing occurred at the Odell Creek site. During that period, livestock were present in the pasture containing the Old Garbage Dump Site, but were not present at the Odell Creek Site. Moose would presumably have equal access to both sites. During the growing season, use by moose is apparently light.

At the eastern end of the Red Rocks Lake (Battle Creek), browsing has limited the growth of young willows to approximately 1 meter, a height that appears to correspond with snow depth. Because cattle do not use this area extensively, moose appear to be responsible. The involvement of moose is underscored by browsing at heights above what could be reached by livestock. The browsing in the Battle Creek area suggests that moose contribute significantly to the willow decline that occurs throughout the refuge.

The side-by-side presence of older, retrogressed-type willows (approximately 3-4 m tall) with younger, arrested-type willows (averaging 54 cm tall) indicates that there has been an increase in browsing intensity. The arrest of young willows indicates that current use by moose exceeds the capacity of the browse resource. As the willow community becomes dominated by arrested-type individuals, the quantity of available browse will become limited to shoots that occur near snow level.

The decline of tall willow may increase stress to moose during years of deep snowcover. Willow shoots 3-4 m tall provide forage under a wide range of snowcover conditions. Once the willow community is converted to short, arrested-type shrubs, moose may lack available forage during years of deep snowcover. Moose population fluctuations may become more extreme.

Season of Use Data
Red Rocks NWR September 10, 1998

Old Garbage Dump Site				Odell Creek Site			
Plant	Use Class	Architecture	Height (cm)	Plant	Use Class	Architecture	Height (cm)
1	5	Arrested	45	1	1	Arrested	72
2	5	Arrested	53	2	1	Arrested	91
3	5	Arrested	63	3	2	Arrested	62
4	4	Arrested	41	4	1	Arrested	64
5	5	Arrested	71	5	1	Arrested	61
6	5	Arrested	63	6	1	Arrested	48
7	5	Arrested	62	7	2	Arrested	68
8	5	Arrested	81	8	1	Arrested	72
9	5	Arrested	43	9	1	U-type	57
10	5	Arrested	46	10	1	Arrested	80
11	5	Arrested	37	11	1	Arrested	41
12	5	Arrested	61	12	1	Arrested	82
13	5	Arrested	42	13	1	Ret-type	130
14	5	Arrested	28	14	1	Arrested	58
15	5	Arrested	43	15	1	Arrested	73
16	5	Arrested	43	16	1	Ret-type	82
17	5	Arrested	67	17	1	Arrested	63
18	5	Arrested	88	18	1	Arrested	67
19	5	Arrested	62	19	1	Arrested	70
20	4	Arrested	41	20	1	Ret-type	110

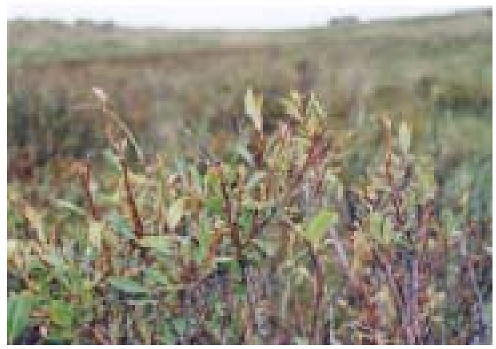
Photographs of Browsing at Red Rocks NWR

September 10, 1998

Willow community at Old Garbage Dump site. Relationships between age and height indicate that this community is in decline.

Willow community at Odell Creek site. This willow community also appears to be in decline.

Arrested-type willow at the Old Garbage Dump site that was inferred to have been heavily browsed by livestock during the 1998 growing season.



Close-up of willow showing evidence of recent browsing by livestock at the Old Garbage Dump site.

The tall leaders (current year growth) of willows at the Odell Creek site contrast strongly with leaders that were cropped at the Old Garbage dump site. Willows at the Odell Creek site were largely unbrowsed during the 1998 growing season.

Literature Cited

Keigley, R.B. and M.R. Frisina. 1998. Browse evaluation by analysis of growth form. Montana Fish, Wildlife & Parks. Helena, MT. 149 pp.

NORTH PASTURE – EAR MOUNTAIN WILDLIFE MANAGEMENT AREA LIVESTOCK GRAZING ANALYSIS

Michael R. Frisina and Quentin Kujala

The 3,080-acre Ear Mountain Wildlife Management Area (EMWMA) is located near Choteau. Lying along the east slope of the Rocky Mountain Front in northwest Montana, the Wildlife Management Area (WMA) was purchased in 1976 by the Montana Department of Fish & Game (F&G) to provide habitat for wildlife and public access to adjacent Federal lands. Other objectives are to provide spring, fall, and winter range for mule deer (*Odocoileus hemionus*) and bighorn sheep (*Ovis canadensis*). The WMA provides important spring and fall habitat for grizzly (*Ursus arctos*) and black bears (*Ursus americanus*). EMWMA also provides essential habitat for a variety of neotropical migrant land birds.

The EMWMA is divided into two portions referred to as the North Pasture (960 acres) and South Pasture (2,120 acres) (Figure 1). Frisina and Kujala (1999) completed a detailed analysis of livestock grazing on the South Pasture of EMWMA. This report provides a detailed grazing analysis of the North Pasture of EMWMA.

Habitat Characteristics

EMWMA is very diverse topographically (Figure 2). Much of the landform, especially in the North Pasture, consists of steep slopes. Sparsely timbered slopes with patches of limber pine (*Pinus flexilis*) characterize the eastern edge of the WMA. The WMA is lowest in elevation along its eastern edge (5,200 feet) and highest in elevation along its western boundary (8,580 feet) at the base of Ear Mountain. For the most part, EMWMA is bounded by private lands along its east and south boundaries and adjoins Bureau of Land Management (BLM) or Forest Service Federal Lands along its western and northern edges.

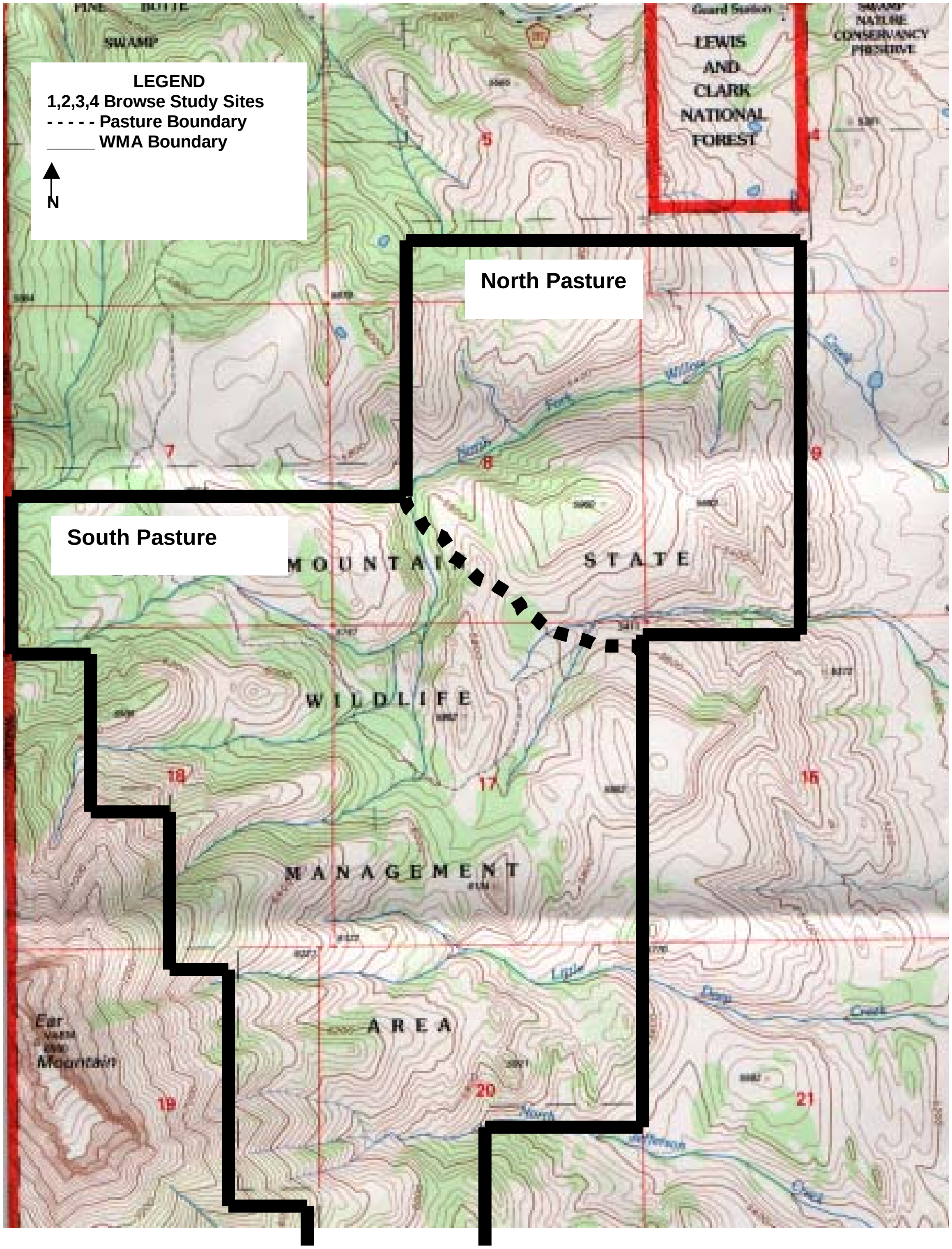


Figure 1. Map showing the location of North and South Pasture and browse study sites in the North Pasture, Ear Mountain WMA.

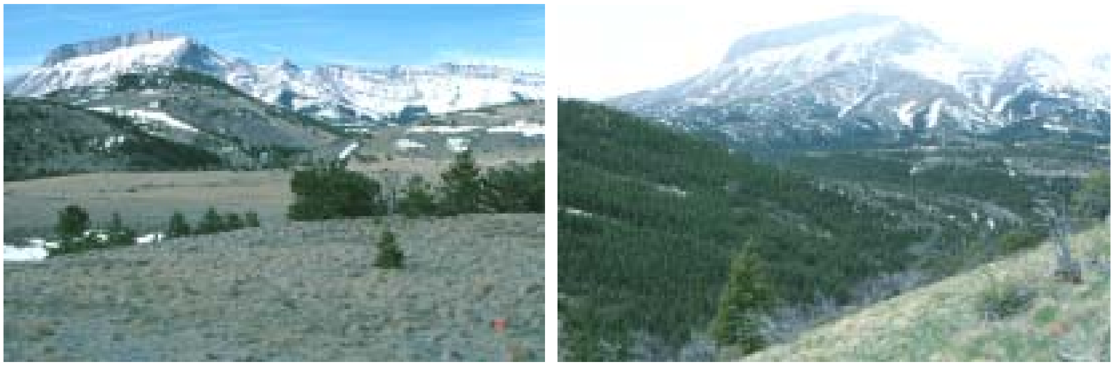


Figure 2. The North Pasture of Ear Mountain WMA is very diverse topographically. Right Photo: Upper portion of North Pasture along its western boundary in foreground. Left Photo: Foreground and mid-portion of photo below mountain peaks is within the North Pasture. (left photo 4/12/99; right photo 5/17/99)

The Lewis and Clark National Forest also administers a discontinuous small land area (160 acres) adjacent to the northeast corner of the North Pasture (Figure 1).

Dense stands of lodgepole pine (*Pinus contorta*) and Douglas fir (*Psuedotsuga mensezei*) are interspersed with parks across the western half of the WMA. Clones of aspen (*Populus tremuloides*) occur along the margins of three different perennial streams and their tributaries. A variety of shrubs are dispersed throughout open and forested rangeland types. Skunkbrush sumac (*Rhus trilobata*), chokecherry (*Prunus virginiana*), wild rose (*Rosa woodsii*), shrubby cinquefoil (*Potentilla fruiticosa*), and Bebb willow (*Salix bebbiana*) are among the commonly occurring species.

The climax grassland type is rough fescue (*Festuca scabrella*). Other frequently occurring native grasses are Idaho fescue (*Festuca idahoensis*), bluebunch wheatgrass (*Agropyron spicatum*), and June grass (*Koeleria cristata*). Timothy (*Phluem pratense*), smooth brome (*Bromus tectorum*), and Kentucky bluegrass (*Poa pratensis*), are among the commonly occurring introduced grass species. Arrowleaf balsamroot (*Balsamorhiza sagittata)*, Hood's flox (*Flox hoodi)*, American bistort (*Polygonum bistortoides)*, pasque flower (*Anemone patens)*, geranium *(Geranium viscosissimum)*, pussy toes (*Antennaria rosea)*, and other forbs common to the Rocky Mountain Front are abundant on the WMA.

Soils on the WMA are generally shallow and rocky.

On September 17, 2000 a lightening strike wildfire swept across the north end of the EMWMA, burning about 400 acres (Figure 3).

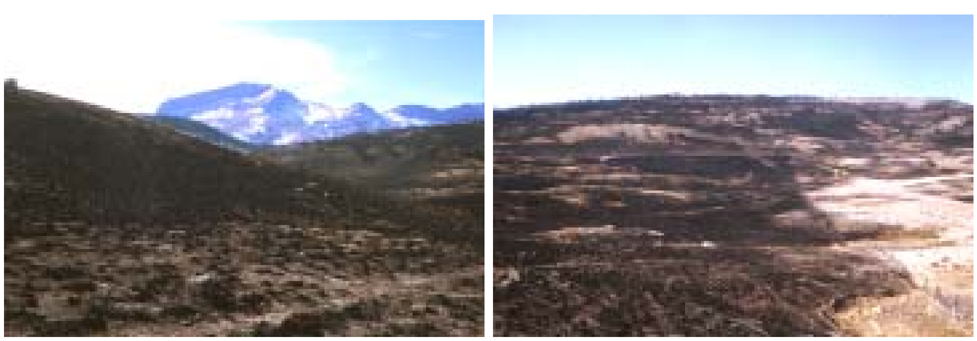


Figure 3. A wildfire on September 17, 2000 burned about 400 acres of the EMWMA.

Habitat Goals and Objectives

The 1992 and 1996 grazing leases between FWP and the Gollehon Ranch state the habitat goal as, “maintain or enhance all native habitats and wildlife use of those habitats” (FWP 1992, FWP 1996). Habitat objectives described in the grazing leases include:

1. Maintain riparian and upland areas currently exhibiting high amounts and qualities of native vegetation.
2. Increase soil amounts, vegetation cover, diversity, and/or litter on sites currently lacking any or all of these components.
3. Reduce vegetation “wolfiness” (excessive decadent material) thereby enhancing forage availability and nutritional value.
4. Maintain adequate forage and cover for resident and seasonal wildlife including, but not limited to, 250 mule deer and 100 bighorn sheep.
5. Additionally, use of the area by elk, grizzly bear, black bear and upland birds shall not be detrimentally impacted.

Livestock Grazing History

Prior to acquisition by F&G in 1976, livestock grazing on EMWMA was the length of the growing season, continuous from year to year, and frequently intensive. The grazing history of the area includes use by cattle, sheep, and horses. Livestock grazing history for the North Pasture from the time of FWP acquisition in 1976 through 2000 is summarized in Table 1. Livestock grazing occurs on both private and public lands adjacent to the North Pasture.

Table 1. Grazing history, since FWP acquisition, of the North Pasture, Ear Mountain Wildlife Management Area.

YEAR	GRAZING AREA	GRAZING TREATMENT	REMARKS	% UTILIZATION by WEIGHT	AUMs GRAZING
1976 through 1991	No Grazing	None			None
1992	During these years the entire North Pasture was available.	Summer growing season	Lease extension allowed		375
1993		After seed-ripe			260
1994		After seed-ripe	Lease extension allowed	44	325
1995		Rest			None
1996	During these years little livestock grazing in the south portion of North Pasture	Summer growing season	Drift fence partially constructed	56	215
1997		After seed-ripe	Drift fence completed	41	162
1998		After seed-ripe			155
1999		Rest			None
2000		Summer growing season.			43

1976-1991
From 1976 to 1991, no livestock grazing was permitted on the WMA.

1991-2000
In 1991, the EMWMA was split into two pastures (South Pasture and North Pasture) separated by an internal electric fence. The South Pasture is about 2,120 acres in size and Frisina and Kujala (1999) described historic livestock grazing on this portion of the WMA. The North Pasture is about 960 acres in size and was leased for cattle grazing to the Gollehon Ranch in 1992. Cattle grazing on the North Pasture is not part of a grazing system involving a larger land base, but is managed for livestock grazing as a separate or "stand alone" unit.

The North Pasture is divided approximately in half from east to west by the North Fork of Willow Creek, a perennial stream (Figure 1). The North Fork of Willow Creek is the primary water source for livestock in the pasture. Since topography is steep, it is not surprising that most cattle presence is in or near the creek bottom.

Livestock Use
FWP entered into a grazing lease arrangement with the Gollehon Ranch that allowed for 260 Animal Unit Months (AUMs) of grazing in June 1992, August 1993, and August 1994 followed by rest for the year in 1995 (FWP 1992). One AUM is defined as one cow with calf grazing for one month. A new lease was issued that allowed for the same grazing cycle to be repeated through the 1999 grazing season (FWP 1996). A one-year grazing lease allowing for 42 AUMs was approved for the 2000 grazing season.

Actual use by livestock has varied from that described in the grazing leases. The timing of grazing has been followed, but variances or extensions were issued allowing for greater AUM use than described in the grazing leases. Actual use allowed by FWP is summarized for each year in Table 1. Reasons for granting grazing extensions is not well documented. Justification for at least the 1994 extension was based simply on "available" grass still present at the end of the prescribed grazing period. Most of the "available" grass was not on primary range and a long distance from water.

Fence Construction
In 1996, construction was begun on a drift fence intended to keep cattle up-slope and out of the riparian areas. The fence was completed in 1997 and essentially eliminated grazing in the southern half of the North Pasture.

Herbaceous Forage Utilization
The grazing leases required livestock utilization to not exceed 50 % use by weight (FWP 1992, FWP 1996). From 1994 through 1997, FWP's local wildlife biologist made utilization measurements annually (Table 1). As is typical of ranges with steep topography and limited water in the uplands, utilization varied greatly at different sites within the pasture. The percentage of plants grazed ranged from about 100 in the bottoms near water to 0 on portions of the uplands. In 1999 FWP expanded its monitoring to include applying the browse architecture method to determined the effect of browsing by cattle and wildlife on shrubs and trees (Keigley 1997, Keigley and Frisina 1998). Transects and exclosures for monitoring long term changes in plant communities on the WMA have also been established by FWP's plant ecologist. This effort is relatively new and the work is unfinished.

Livestock Grazing Evaluation

During 1999 the EMWMA's North Pasture received yearlong rest from livestock grazing, which completed a second full cycle of the grazing system. During this eight year time period, except for rest years, cattle use ranged between 375 AUMs and 155 AUMs (Table 1). The average AUMs provided from 1992 though 1998 was 249. The rest treatment years of 1995 and 1999 were not included in these calculations. For the 2000 grazing season 43 AUMs were allotted which was determined by basing the stocking rate on the amount of primary cattle range available in the north pasture.

Herbaceous Vegetation

During years livestock grazing occurred, from 1992 through 2000, forage utilization measurements were made to monitor compliance with a maximum utilization level of 50% by weight as prescribed by the grazing agreements (FWP 1992, FWP 1996). As a result of steep topography and limited distribution of water, utilization levels varied across the pasture. Average utilization levels for the North Pasture ranged from a high of 56 % in 1996 to a low of 41 % in 1997 (Table 1). The three-year average (one rest year excluded) was 47 %. Utilization levels were not separated by range suitability types but were most intense on primary range, with little if any utilization common on the upland slopes removed from water. Utilization was not measured for the 1998 and 2000 grazing season, but was lower than the average due to reduced stocking rates (Table 1).

Although ocular observations at the exclosure in the southeastern portion of the North Pasture indicates herbaceous vegetation is adequately maintaining vigor and species diversity, some noticeable trailing effects are apparent along the drift fence constructed in 1996 and 1997. This fence was constructed to encourage cattle to make better use of the steep uplands and less use of the riparian areas and steep bottoms. Cattle concentrate along the fence and cause noticeable soil disturbance in the form of trails (Figure 4). The drift fence has reduced use in the riparian areas, except for three water gaps cattle used for watering. However use on the bottoms near the eastern edge of the North Pasture is intense with some soil disturbance apparent in the vicinity of the exclosure.

Figure 4. Cattle trails along the North pasture drift fence.

Shrubs and Trees

A variety of woody species palatable to both large wild ungulates and cattle occur on the EMWMA. An evaluation of browsing effects on woody species was conducted using techniques described by Keigley (1997) and Keigley and Frisina (1998). Browse use was evaluated at four sites in areas of the North Pasture used by both wildlife and cattle. A description of observations at the three sites follows:

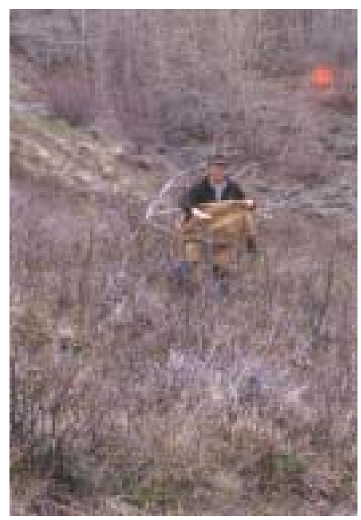
Site 1: Chokecherry (*Prunus virginiana*)

Site 1 is located upslope from the middle water Gap and on the north side of the North Fork of Willow Creek (Figure 1 & Figure 5) A browsing history from 1981 through may 1999 was established by analysis of annual growth rings (Table 2).

Table 2. Browsing history for chokecherry (*Prunus virginiana*) at site 1, North Pasture Ear Mountain WMA, 1999.

Stems within the browse zone.					Stems grown beyond browse zone.	
Sample Size	% intensely browsed	Avg. Year of elongation	Avg. Year intense browsing began	Average age of release from intense browsing	Sample Size	Avg. Year of elongation
10	95	1987	1992	1995	3	1981

From 1981 to 1992, with only wildlife browsing, chokecherry was able to grow and achieve its typical stature (light to moderate browsing). From 1992 through 1994 browsing was intensive (Table 2). The cattle grazing system was initiated on the WMA in 1992 (Table 1). Some release from browsing has occurred since 1995. This release can be observed, but chokecherry stems



Site 1 is located upslope and on the north side of the North Fork of Willow Creek. Chokecherry stems, within the browse zone, were 95% intensively browsed at this site. From 1991 through 1994 cattle grazed Site 1; since 1995, only browsing by wildlife has occurred.

Figure 5. Chokecherry stems (*Prunus virginiana*) were intensively browsed at Site 1 (continued on following page).

Some growth release from reduced browsing has occurred since 1995, but chokecherry stems at the site are still being intensively browsed. Photos were taken on 5/17/99.

Figure 5. Chokecherry stems (*Prunus virginiana*) were intensively browsed at Site 1.

at the site are still being intensively browsed (95%). In 1995 the North Pasture was rested from livestock grazing and in 1996 a drift fence excluding Site 1 from livestock grazing was completed.

It appears with only wildlife browsing (from 1981-1991), chokecherry plants were able to reach their typical stature. After 3 years of intensive browsing by a combination of cattle and wildlife, chokecherry plants exhibited intensively browsed architectures (arrested and retrogressed). Only wildlife browsing has occurred at Site 1 since 1995, yet 95% of the chokecherry stems were intensively browsed. Since intense browsing can inhibit the long-term productivity and growth of shrubs (Garrison 1971, McKell 1989), it may be that the after effects of intense cattle browsing damaged the chokecherry stems to a point where they are no longer able to withstand current browsing by deer. One can see an improvement in stem growth since cattle browsing ended, but net stem growth is not enough for the stems to develop release type architecture.

Site 2: Middle Livestock Water Gap – Black Cottonwood (*Populus trichocarpa*), Dogwood (*Cornus stolinifera*), Rose (*Rosa woodsii*).

This site was divided into 2 components; **Inside the Water Gap** and **Outside the Water Gap** (Figure 6). **Inside the Water Gap** refers to a small area (.08 acre) made available for cattle to obtain water. The area Outside the Water Gap is immediately adjacent to the water gap, but within the area not available to livestock as a result of the drift fence constructed during 1995 and 1996 (Table 1).

Inside the Middle Water Gap

Cattle have access to the area within the water gap as described in Table 1. The water gap was created in 1995 when the drift fence excluding cattle grazing from a portion of the North Pasture was constructed. The water gap was essential as a livestock-watering source.

Figure 6. Upper left photo taken from drift fence looking into the water gap area; upper right photo taken from drift fence inside the water gap looking toward the area outside the water gap where livestock grazing is excluded; lower right photo taken from within the water gap area; lower left photo looking out of water gap area. Note the difference in residual herbaceous vegetation outside the water gap as compared to inside (photos taken 5/17/99).

Almost all of the cottonwood stems within the browse zone (50-150 cm tall) were dead. There were not enough plants left alive to measure. There were a few living dogwood (*Cornus stolinifera*) that had grown beyond the browse zone and no living dogwood within the browse zone. The only living rose bushes were those mechanically protected by cottonwood plants. All rose present was intensively browsed.

Outside the Middle Water Gap

In the area outside the water gap cottonwood, dogwood, and rose stems were 10, 0, and 0% intensively browsed respectively (N=20 for each species).

Comparison

Browsing was much less intensive for cottonwood, chokecherry and rose outside the water gap as compared to inside the water gap (Figure 7).

Figure 7. Left photo is of a lightly browsed cottonwood stem outside the water gap. Right photo is of cottonwood stems within the water gap killed by a combination of intensive browsing and mechanical damage.

There was greater herbaceous ground cover outside the water gap as compared to inside the water gap (Figure 8). Although we did not measure herbaceous species composition, horsetail (*Equisetum spp.)* was common outside the water gap, but we observed none within the water gap.

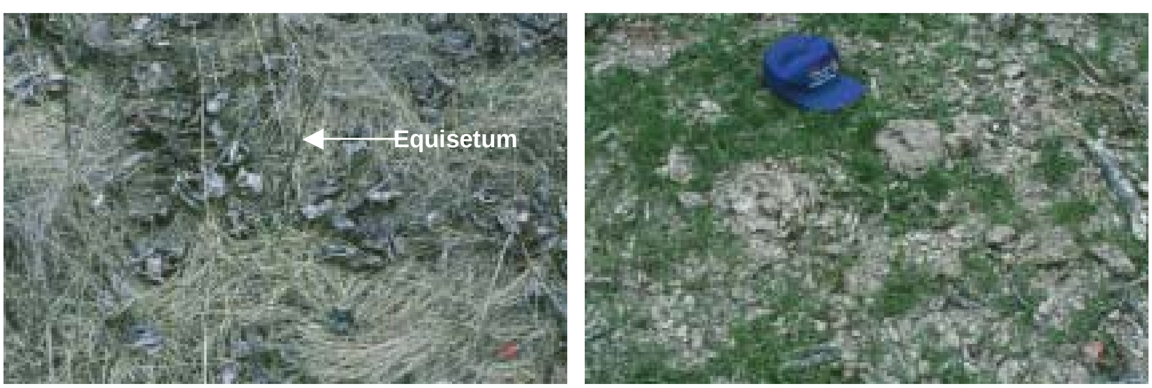


Figure 8. Right photo is within the water gap; left photo is outside the water gap. Note that most of the ground litter in the right photo is cow dung with a few pieces of broken shrub or tree twigs while most of the litter in the left photo is cottonwood leaves and residual grasses. Also note that equisetum is only present in the left photo. Photos were taken 5/17/99.

Since both cattle and wildlife can utilize the water gap, but only wildlife are capable of using the area outside the water gap, the greater browsing intensity inside the water gap must be a result of cattle use.

Site 3: Upper Livestock Water Gap – Aspen (*Populus tremuloides*).

This site is located in the upper southwest corner of the North Pasture near its west boundary (Figure 1). Browse architecture was measured for 20 aspen (*Populus tremuloides*) stems inside and 20 aspen stems outside of the water gap. Aspen stems outside the water gap (cattle excluded by fence) were 40% intensively browsed as compared to 60% of the stems inside the water gap (area available to cattle) intensively browsed (Figure 9). Of the stems sampled outside and inside the water gap 35% and 25%, respectively exhibited released type architecture respectively. This indicates the stems had experienced more intensive browsing in the past. The release from browsing may have been due to the effect of the drift fence constructed during the 1995 and 1996 grazing seasons (Table 1).

Figure 9. Left photo is of an aspen (*Populus tremuloides*) stem outside the water gap where 40% of the stems sampled were intensively browsed. Right photo is of an aspen stem inside the water gap where 60% of the stems sampled were intensively browsed.

Site 4: Lower Livestock Water Gap – Chokecherry (*Prunus virginiana*), Dogwood (*Cornus stolinifera*), Rose (*Rosa woodsii*), and Black Cottonwood (*Populus trichocarpa*).

This site is located in the northeastern portion of the North Pasture near where the North Fork of Willow Creek crosses the pastures eastern boundary (Figure 1). Since this water gap is located near the gates used to place cattle in the pasture and is near the largest portion of relatively level land within the pasture, it receives the most intensive use by cattle. Since there was not a comparable location from which cattle are excluded adjacent to the lower water gap, we only measured stems inside the water gap area available to cattle.

Chokecherry stems within the browse zone were 100% intensively browsed (N=20, Figure 10). Ageing of 11 stems by counting growth rings indicated that the average year in which this intensive browsing began was 1992. A visual inspection of individual stem growth segments indicates browsing was relatively most intense from 1992 through 1996. Although browsing is still intense, it appears that more of the annual stem growth was left after browsing during 1997 and 1998 compared to 1992 through 1996.

Dogwood stems within the browse zone were 100% intensively browsed (N=12). Rose and cottonwood stems within the browse zone were each 85% intensively browsed (N=20 for each).

Intensive browsing began in 1992, the year cattle were introduced (Table 1), and remained intensive through the 1996 grazing season. During 1997, the first grazing season after the drift fence was completed, and 1998, some decrease in the intensity of browsing can be observed, but was probably not enough to allow for recovery (Figure 10). The data suggest cattle were the primary cause for this intensive browsing.

Figure 10. Chokecherry (*Prunus virginiana*) stems within the browse zone at Site 4 were 100% intensively browsed. Although still intensively browsed, less of the annual growth segment was removed during 1997 and 1998 compared to 1992 through 1996.

Analysis Summary

With the exception of some noticeable trailing along fences, herbaceous vegetation seems to be maintaining its health and vigor under the current grazing system.

An increase in browsing from light to moderate to intense began in 1992, the year livestock grazing was introduced to the North Pasture of Ear Mountain WMA. Further, a slight lessening in browsing intensity was observed to coincide with the construction of a drift fence designed to restrict livestock use along the North Fork of Willow Creek to 3 water gaps and encourage increased cattle use of the steeper upland sites. At the upper and middle water gaps browsing was significantly more intense inside the water gaps where cattle have access than in adjacent areas outside the water gap where cattle are excluded. Since Ear Mountain is a WMA, cattle grazing is a secondary land use and intensity of use within water gaps by livestock is an issue of concern. This information and the fact that wintering deer, elk, and bighorn sheep occur at low densities on the WMA, indicates most of the browsing impacts on woody vegetation are the result of cattle grazing. During winter there are approximately 5 or less large wild ungulates per square mile and approximately 10 or less large wild ungulates per square mile during summer and fall.

Data collected at Site 1 for chokecherry indicates intense cattle browsing that occurred between 1992 and 1996 may have damaged the chokecherry stems to a point where they are no longer able to withstand current browsing by deer.

Intensive browsing was documented for five woody species in the North Pasture. Cattle grazing at stocking rates, which occurred between 1992 and 1996, inhibited the ability of browse species to develop their potential stature and maintain their potential vigor.

Stocking Rate

The grazing arrangement with the Gollehon Ranch for the years 1992 through 1999 allowed the North Pasture to provide up to 260 AUMs in three out of four grazing season (FWP 1992, FWP 1996). This represents a permitted stocking rate of 3.7 acres per AUM. Every fourth year the North Pasture was rested from livestock grazing. In reality, the actual stocking rate varied by year and ranged from 2.6 acres per AUM to 6.2 acres per AUM for non-rest years. In 2000 a one-year lease was issued and the actual stocking rate was 22.3 acres per AUM.

The aforementioned stocking rates were calculated using 960 acres for the North Pasture's size, without regard to range type classification. Much of the North Pasture is for cattle, topographically steep with long distances from water and thus not suitable for cattle grazing. This was not taken into consideration when the stocking rates for earlier leases were determined. We classified the North Pasture for livestock grazing purposes into 2 range types, primary range and non-suitable range (Figure 11). Due to the rapid change from relatively level land near water to steep slopes removed from water, we did not include a secondary range type. We determined there to be 125 acres of primary range available for livestock grazing in the North Pasture. There are an additional 76 acres of potentially primary range that is the stream banks of a tributary of the North Fork of Willow Creek which is excluded from livestock grazing due to construction of the drift fence in 1995 and 1996 that created the three livestock water gaps. This leaves a remaining 759 acres of range unsuitable for livestock grazing.

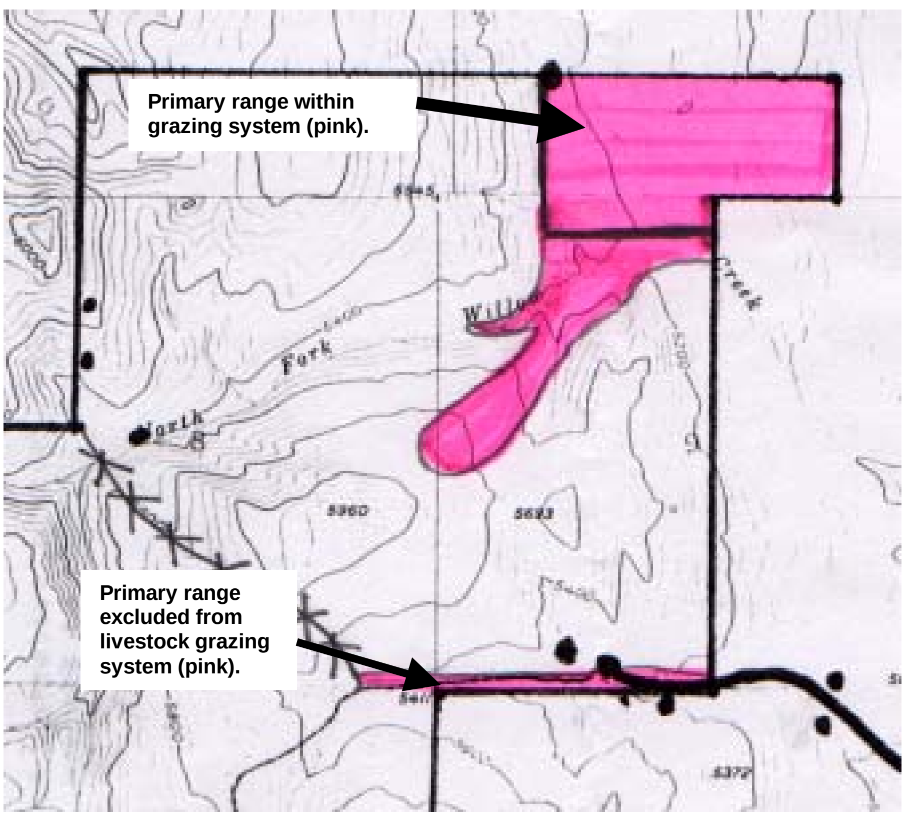


Figure 11. Rangeland classification for livestock grazing, North Pasture of Ear Mountain WMA.

Range Classification	Area in Acres
Primary (in system)	125
Primary (excluded from system)	76
Unsuitable (white area)	759
TOTAL	960

By recalculating the stocking rates based on the classification of primary range, one can obtain a more accurate picture of grazing intensity. From 1992 through 1994 all 201 acres (125 + 76) of the primary range in the north pasture were available for cattle grazing. Using actual AUM levels in Table 1, the stocking rate varied from .5 acres per AUM to .8 acres per AUM. In 1995 the North Pasture was rested from livestock grazing. From 1996 through 1991 the 76 acres of primary range along the North Fork of Willow Creek was excluded from livestock grazing resulting in 125 acres of primary range available for livestock grazing. Using Actual AUM levels in Table 1, the stocking rate varied from .6 acres per AUM to .8 acres per AUM from 1996 through 1998. In 1999 the North Pasture was rested from livestock grazing. Since all drift fences were left open or taken down, the stocking rate on primary range was 4.7 acres per AUM. Obviously, some limited livestock grazing does occur on portions of the non-suitable range, but since the Forest Service considers an appropriate stocking rate of 2 to 4 acres per AUM for primary range in this area (Appendix A), stocking rates for the North Pasture have been very high for all years except the rest years of 1995 and 1999 and the 2000 grazing season when the stocking rate was revised to take into account the actual amount of primary range available for grazing.

The 759 acres of non-suitable range amounts to 79% of the land base in the North Pasture. An adjusted stocking rate based on the remaining 201 acres of primary range available for cattle grazing and 2 to 4 acres per AUM recommended by the Forest Service makes the 43 AUMS of grazing permitted in 2000 (4+ acres per AUM) more appropriate as a stocking rate than that permitted in prior leases. Since most of the browse species are located near water and/or associated with the primary range type the intense stocking rates permitted during the 1990's were responsible for the high levels of intense browsing documented by this analysis.

Discussion

Trees and shrubs are important habitat components at EMWMA. Aspen, cottonwood, and several shrub species provide food and cover for grizzly bears, mule deer, and bighorn sheep. They also provide essential nesting and summer habitat for many species of neotropical migrant land birds. Cattle browsing has negatively impacted aspen and several species of shrubs (at stocking densities experienced from 1992 through 1998). Browse plants at sites 1 through 4 would eventually disappear from the plant community if browsing at these intensities continues for several years.

The timing of grazing associated with the grazing system may also be significantly contributing to impacts on browse plants. The grazing system allowed cattle to graze the pasture 3 out of every 4 years. The grazing system provides only 1 yearlong rest period every 4 years. In a year when the North Pasture is scheduled for early or growing season grazing, most forage plants (herbaceous and woody) are green for most of the grazing period. For 2 years following grazing during the growing season, the pasture was grazed during late summer or early fall. During this treatment it is not unusual for the herbaceous vegetation to be dry and less palatable than many of the shrub species. The result is that shrubs are still green and the most palatable forage in the pasture. In such situations, browsing can become very intense on primary range sites.

Woody species are more vulnerable than herbaceous plants to intense grazing after the year's growth is completed. The growing points of shrubs and young trees are often within the zone readily available to browsing animals. Woody species store a proportion of their food reserves in stems (in previous years growth) many of which are often within the browse zone (Garrison 1971).

Recommendations

To address the aforementioned impacts to browse plants, adjustments in the approach to livestock grazing are necessary. Reducing the North Pasture stocking rate to a level of about 42 AUMs and changing the grazing system sequence to a three treatment strategy, similar to that described by Egan (2000), would effectively address concerns raised for browse plants in this analysis. However, since the grazing capacity analysis does not provide any allowance for secondary range, we recommend a 70 AUM stocking rate for the 2001 grazing season. An evaluation will be conducted at the end of the 2001 grazing season and an appropriate long-term stocking rate will be determined.

The adjusted stocking rate eliminates dependence upon non-suitable range to provide cattle forage. The adjusted stocking rate realistically addresses the availability of forage produced on the land base. An important consideration is that when cattle are in a pasture, they never quit using primary range. Primary range is used intensively first and as secondary range use increases, utilization on primary range continues. This is because water and resting sites are associated with primary range.

In the past, problems associated with steep topography were addressed by using drift fences to control cattle distribution, resulting in trailing problems, intense trampling and utilization at water gaps, and significant man-hours required to maintain permanent drift fences. We recommend that for the near future, drift fences be left open and that, when possible, they be removed. Removal of drift fences and stocking rate adjustments will effectively diffuse livestock use throughout the riparian corridors and other heavily used areas.

The 3-treatment grazing strategy for the North Pasture would provide rest every third year, instead of the current complete rest every fourth year. A 3-treatment approach would also allow for the late summer use once every third year compared to the current twice in 4 years.

In summary, a reduced stocking rate and adoption of a three-treatment grazing approach, following rest-rotation concepts described by Hormay (1970) and Egan (2000), would reduce browsing intensity, browsing frequency, and increase the frequency of season-long rest treatments.

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Provided courtesy of Brad McBratney
Forest Service, Lewis & Clark National Forest, Rocky Mountain Ranger District

Quinten, These are for primary range. Secondary will some percentage less based on your property, distance to water, steepness, etc. Brad

INSTRUCTIONS

1. COMPUTE ANIMAL UNIT MONTHS ACTUALLY PRODUCED, OR PRODUCTION CAPABILITY OF HAY, GRAIN, PASTURE, ROUGHAGE, AND OTHER FEED FROM APPROVED DESIGNATED BASE PROPERTY BY THE VARIOUS CROPS OR RANGE TYPES.

2. ALLOWANCE PER AUM* ARE AS FOLLOWS: (IF OTHER ALLOWANCES ARE USED, GIVE EXPLANATION.)

	Acres Per AUM		
Type	Good	Fair	Poor
MEADOW PASTURE (CUT)	3.0	4.0	5.0
MEADOW PASTURE (UNCUT)	.3	.4	.5
IMPROVED PASTURE (CUT)	2.5	3.0	4.0
IMPROVED PASTURE (UNCUT)	.2	.3	.5
ALFALFA (3RD CROP PASTURE)	.7	1.0	1.5
GRAIN STUBBLE	10.0	10.0	10.0
SUMMER RANGE - SUITABLE	1.5	2.5	5.0
WINTER RANGE - SUITABLE	2.0	3.0	5.0
SPRING-FALL RANGE - SUITABLE	2.0	2.5	5.0
OTHER (SPECIFY)	___	___	___
	___	___	___
	___	___	___

I generally figure 2-4 acres / AUM. Above 2 is very good sites. You would be around 2000# / acre production to be better than 2 acres / AUM. Very good ranch site.

*1 AUM = 1 - 1000-LB. ANIMAL OR EQUIVALENT FOR 1 MONTH BASED ON CONSUMPTION OF 26 POUNDS OF DRY MATTER PER DAY.

3. AUM FACTOR

Class	Factor
MATURE COW	1.00
MATURE COW W/NURSING CALF	1.32
YEARLING (9-18 MONTHS)	.70
WEANER CALF	.50
BULL	1.50

Class	Factor
MATURE SHEEP AND GOATS	.20
EWE W/LAMB AND NANNY W/KID	.30
HORSE AND MULE	1.20
BURRO OR DONKEY	.80
SWINE	.50
BISON	1.00

4. COMPUTE THE PROPORTIONATE NUMBER OF MONTHS' FEED WHICH MUST BE PRODUCED FROM BASE PROPERTY BY MULTIPLYING THE NUMBER OF MONTHS LIVESTOCK ARE NOT PERMITTED ON NATIONAL FOREST SYSTEM LANDS BY THE MINIMUM PERCENTAGE REQUIREMENT FOR THE FOREST OR RANGER DISTRICT. DETERMINE THE TOTAL NUMBER OF QUALIFYING LIVESTOCK FROM PRODUCTION LISTED BY DIVIDING THE TOTAL AUM PRODUCTION BY THE MONTHS' REQUIREMENT OBTAINED IN THE PRECEDING COMPUTATION AND DIVIDING THE RESULT BY THE APPROPRIATE AUM FACTOR. COMPARE QUALIFYING NUMBER WITH THE NUMBER UNDER PERMIT OR APPLIED FOR.

The Condition of Browse Plants at the Theodore Roosevelt Memorial Ranch (TRMR)

Richard B. Keigley and Gary R. Olson

Introduction

The Theodore Roosevelt Memorial Ranch (TRM), owned and operated by the Boone and Crockett Club, spans 6,000 acres along the Rocky Mountain East Front. The ranch is located west of Dupuyer, Montana, on the forks of Dupuyer and Scoffin Creeks. Each fall, mule deer migrate from the Bob Marshall Wilderness and adjacent Lewis and Clark and Flathead National Forests to the ranch and adjacent private lands. Winter counts and classifications have been conducted since the mid-1970's by Montana Fish, Wildlife & Parks personnel. In addition to mule deer, domestic livestock, whitetailed deer and elk compete for space and forage on the winter range.

Browse species such as chokecherry, aspen, serviceberry, red osier dogwood, horizontal juniper, and willows are utilized by all ungulates in the area. The Dupuyer Creek winter range shows evidence of severe over-browsing on these species. Coincidentally, mule deer and elk populations have historically been higher here than other areas along the mountain front.

Over the past 22 years, mule deer densities have been calculated at over 75 deer per square mile over the entire winter range and up to 200 per square mile on the TRM itself. Winter ranges are occupied from mid-November through May. Winter counts are conducted in January and again in March to assess fawn and adult survival. An average of 2,100 mule deer are surveyed annually, with fawn/doe ratios of 71, fawn/adult ratios of 54, and buck/does ratios of 33 (ratios are expressed as animals per 100 does or adults).

Mule deer migrate back to higher elevation summer ranges in mid- to late-May, traveling as far north as Glacier National Park and westward to the South Fork of the Flathead River. Less than 15 percent of the wintering population remains along the mountain front during the summer. Movements back to winter range may occur in early October, with the majority of animals present by November 15th.

As background for a more comprehensive study, we collected data in September and October 1999 from which to assess the impact of ungulates on browse plants. There were three general objectives: 1) determine the current level of browsing intensity, 2) reconstruct histories of browsing, and 3) determine the effect of browsing on rate of stem growth.

Methods

Study Sites

In 1999, data were collected at five study sites: Lenstra, Middle Draw, Upper Creek Bottom, High Tower Pasture, and Airstrip Ridge. Two-hectare exclosures were constructed in 1988 at the Lenstra, Middle Draw, and Upper Creek Bottom. The exclosures are partitioned into areas fenced by barbed wire approximately one-meter high (accessible to wildlife but not cattle) and areas surrounded by fence approximately two meters tall that excludes both cattle and wildlife.

Current level of browsing intensity

Current browsing levels of aspen, chokecherry, and willow were determined using the criterion defined in Keigley and Frisina (1998). At each site, plants 50 - 150 cm tall were classified by architecture. Arrested- and retrogressed-type architecture would be indicative of current intense browsing. Plants 50 - 150 cm tall with uninterrupted-growth type architecture would be indicative of current light-to-moderate browsing.

Browsing history

Browsing histories at four sites were reconstructed based on methods described in Keigley and Frisina (1998). Browsing-related architectures are produced during the time when a terminal leader grows through the browse zone. If browsing modifies a stem (for example, by causing the development of a cluster of twigs), that modification remains at a fixed height above the ground. A site's browsing history is recorded in the growth form of stems that lie within about 1.5 m above ground level. By examining plants of different age, one can reconstruct a site's browsing history. At each site, we reconstructed a qualitative browsing history based on estimates of plant ages and the architectures exhibited by plants of different age.

Older aspen have grown to tree stature. Younger aspen are heavily browsed.

By determining the actual stem age from counts of tree rings, we reconstructed a year-by-year long-term history of aspen use at the Lenstra exclosure site. Years of light-to-moderate browsing were determined from uninterrupted-growth type plants using stem age at 1-m tall. The onset of intense browsing was determined using the method described in Keigley and Frisina (1998, page 100).

Using similar approaches, we determined the years when an increase in browsing intensity occurred in chokecherry (*Prunus virginiana*) at the Upper Creek Bottom exclosure site, Bebb willow (*Salix bebbiana*) at the High Tower Pasture site, and horizontal juniper (*Juniperus horizontalis*) on the ridge on which the airstrip is located). The onset of intense browsing was calculated by:

Y_I = (Year the stem was a terminal leader) + (the number of years until it was intensely browsed)

$$Y_I = (1999 - A_l + 1) + (A_{db} - A_{dc} + 1),$$

where Y_I is the year that intense browsing began, A_l is the number of annual rings on a live section of the stem located just below the segment of stem killed by browsing, A_{db} is the number of annual rings at the base of the dead segment (this is assumed to have been produced in the same year as the segment represented by A_l), and A_{dc} is the number of annual rings on the dead stem segment, just below the point at which browsing produced a dense cluster of twigs. When calculating the year that the segment was a terminal leader, one year is added to account for the growth ring that was produced the year the stem was collected. When determining the number of years until the stem was intensely browsed, one year is added because intense browsing occurred after the period $A_{db} - A_{dc}$.

Stem Growth Rate

Three methods were used to measure stem growth rate: 1) total net annual growth rate, 2) the net growth rate that occurred during the previous three years, and 3) the growth rate that occurred over a standard length of stem.

Total net annual growth rate. At the Upper Creek Bottom exclosure site, we measured total net annual growth rate (NAGR) of 10 chokecherry plants growing inside the exclosure and 10 plants growing outside. NAGR is based on the total age of the stem and is calculated as follows: NAGR = H_{pyg} / (A_s - 1). H_{pyg} is the height to previous-year-growth; A_s is the number of annual rings at the base of the stem. As above, one year is subtracted from A_s to correct for the annual ring produced during the current growing season. NAGR provides an overall perspective of stem growth. On sites where snowcover protects young plants from being browsed until they attain a certain height, NAGR may reflect an early period of rapid height growth (during protection) and a latter period of inhibited height growth (when the plant is tall enough to have been exposed to browsing).

Top: Heavily browsed chokecherry.
Bottom: Chokecherry inside exclosure.

Growth rate the preceding three years. Using each of the plants selected for NAGR measurement, we also determined the net growth rate that had occurred for the preceding three years (in this case, 1998, 1997, and 1996). On a given plant, the stem having the tallest current-year-growth was selected for measurement. The length of the current-year-growth segment was not included in the 3-year average because a significant portion may be consumed during the coming winter. The annual segments were identified from bud scars. The year of production was interpreted from the position of current-year-growth relative to older growth segments.

Total length was measured from point-of-attachment to point-of-attachment. Often, a younger stem segment developed from a lateral bud on the older segment (as opposed to the terminal bud), causing part of the older segment to extend above the point-of-attachment with the younger segment. The length above the point-of-attachment was not included in the measured length.

On occasion, complete annual segments die and current year growth develops from a dormant bud on a segment that is older than previous-year-growth. For example, if the 1997 and 1998 growth segments die, current-year-growth in 1999 may develop from a dormant bud on the 1996 growth segment. If a segment year was not represented, that year was scored as a zero. In the example above, the surviving length of the 1998 and 1997 segments would be zero.

Growth rate over a standard length of stem. Elongation rates of horizontal juniper were based on measurement over a standard length of stem (25 cm). This method was adopted because, due to its prostrate growth form, the stems of horizontal juniper often have no obvious point of origin from which to base total NAGR. The rate (R_l) was calculated by: R_l = L / (A_l - 1), where L is the length of the stem and A_l is the number of annual rings at the oldest end. Length was measured to previous-year-growth.

Results/Conclusions

Current level of browsing intensity

Aspen (at the Lenstra exclosure), chokecherry (at the Middle Draw, Upper Creek Bottom, and High Tower pasture sites), and Bebb willow (at the High Tower pasture site) were 100% intensely browsed. At each of those sites, no plants 50 - 150 cm tall were found to exhibit uninterrupted-growth-type architecture; all plants 50 - 150 cm tall exhibited arrested- or retrogressed-type architecture..

Browsing history

Qualitative browsing history. The relationship between plant age and architecture of aspen at the Lenstra exclosure site indicate that there has been an increase in browsing intensity (see photo on page 66). Young aspen exhibit either arrested- or retrogressed-type architecture, indicating that the current browsing level is intense. Older aspen exhibit uninterrupted-growth-type architecture and grew to tree stature during a prior period of less-intense browsing.

At the Middle Draw exclosure site, only arrested-type chokecherry plants were seen, but aspen growing nearby indicate a history similar to that which occurred at the Lenstra site. At the Upper Creek Bottom exclosure site, retrogressed-type chokecherry plants indicate a similar pattern: an early period of light-to-moderate browsing followed by a later period of more-intense browsing.

At the High Tower Pasture site, only arrested-type chokecherry plants were seen. Retrogressed-type Bebb willow indicate a browsing history similar that which occurred at the Lenstra, Middle Draw, and Upper Creek Bottom exclosure sites.

Long-term browsing history of aspen at the Lenstra Exclosure site. The ages of uninterrupted-growth type stems, indicate that light-to-moderate browsing occurred from 1915 (represented by the oldest aspen stem) to 1992. Aspen have been intensely browsed at the Lenstra site since 1989. Over the period 1989 - 1992, some aspen were intensely browsed while others escaped browsing. After 1992, browsing has prevented aspen from attaining tree stature.

Onset of intense browsing of chokecherry, willow, and juniper. Two retrogressed-type Bebb willows were collected at the High Tower Pasture site. The willow stems elongated in 1969 and 1975 respectively, and first experienced intense browsing in 1982 and 1983, respectively.

Cores were taken from two Bebb willow stems that were approximately 3.5 m tall. The stems, at the point where the cores were taken, were terminal leaders in 1942 and 1959, respectively. At present, browsing prevents young Bebb willow from growing taller than about 50 cm, so the stems that were cored must have grown out of the browse zone when browsing was less intense than at present. Based on the data taken, Bebb willow was light-to-moderately browsed in 1942 and 1959; in the early 1980s, browsing level increased from light-to-moderate to intense.

Sections from two retrogressed-type chokecherries were collected at the Upper Creek Bottom exclosure site. One stem elongated in 1964, grew to a height of 190 cm, and was first intensely browsed in 1972. As current browsing has killed chokecherry stems at an average height of 92.2 cm (±5.6 SE, N = 10), the chokecherry that elongated in 1964 grew approximately 1-m taller than plants do at present.

The second chokecherry stem elongated in 1972, grew to a height of 137 cm, and was first intensely browsed in 1979. This plant also grew taller than plants now do, but did so after browsing intensity increased in 1972. The second chokecherry stem did not grow as tall as chokecherry stem that elongated in 1964. These limited data suggest the following scenario. Chokecherry experienced light-to-moderate browsing from at least 1964 up to 1972, at which time browsing intensity began to increase. From 1972 to the latter 1970s, browsing intensity increased. A chokecherry stem that elongated in 1981 failed to grow taller than 99 cm, indicating that by about 1981, browsing had reached its present intense level.

Two out of five juniper stems collected from the Airport ridge indicate that browsing intensity increased in the early 1980s (1981 and 1982, respectively). Three of the five stems were first intensely browsed in the mid-1990s (1993, 1993, and 1996).

Stem Growth Rate

Chokecherry at Upper Creek Bottom exclosure site. Chokecherry plants growing outside the exclosure had an NAGR of 8.4 cm/y (SE ± 0.6, N = 10), while the NAGR of plants growing inside was 13.7 cm/y (SE ± 2.0, N = 10; Figure 3). ANOVA distinguished a difference between inside and outside at $P < 0.03$.

The growth rate based on the previous three years (1996, 1997, and 1998) was 3.1 cm/y (SE ± 1.5, N = 10) for plants growing outside the exclosure, and 11.0 cm/y (SE ± 2.1, N = 10) for plants growing inside. ANOVA distinguished a difference between inside and outside at $P < 0.009$.

Both methods of growth rate measurement indicate that browsing reduces growth rate. The maximum height of plants sampled outside the exclosure was 118 cm tall. The oldest of these plants was established in 1981. It appears that, for about the past two decades, browsing has prevented chokecherry plants from growing taller than 60 - 120 cm. Snow and topography are likely important factors in chokecherry height variation at this site.

Horizontal juniper growth rate. Of the data collected, the Middle Draw site provides the best indication of the effects of juniper browsing. Inside the 2-m tall exclosure, the average stem growth rate was 9.0 cm / y (± 1.5 SE, N = 5), while outside the exclosure, where juniper may be browsed by both deer and cattle, the growth rate was 2.9 cm / y (± 1.2 SE, N = 5).

At the Airstrip site, horizontal juniper was collected from two areas, one in an area of snow accumulation (in the lee of Limber pines), and an area in which snow is typically blown free, where plants are presumed to be more exposed to browsing. The average stem growth rate of exposed juniper was 1.8 cm / y (± 0.4 SE, N = 5; four lengths were measured to 20 cm), while the growth rate of protected juniper was 4.1 cm / y (± 1.9 SE, N = 5; one length was measured to 20 cm). In addition to differences in exposure to browsing, the sites likely differ in moisture availability.

The juniper stems collected from the exposed area at the Airport site consist of two distinct regions, one in which the stem has grown relatively straight (this on the older portion of the stem), and a younger region in which segments are clustered. Because the tips are browsed, the clustering is presumed to have been caused by browsing. (Age at the juncture of these regions was the basis for the juniper browsing history dates that were described above.) The average growth rate of the older region of the stem was 4.8 cm / y (± 1.1 SE, N = 5), while the growth rate of the younger region was 0.4 cm / y (± 0.0 SE, N = 5). In part, the differences in growth rate may be affected by stem age, but as evidenced by stem clustering caused by browsing, an increase in browsing pressure must play an important role.

Horizontal juniper was not evenly distributed at Middle Draw site. Outside the exclosure fences, horizontal juniper was relatively easy to find. Inside, the 2-m tall fence, juniper was less easy to find. Inside the 1-m tall fence, horizontal juniper could not be found. This distribution suggests the following possibility.

Because the grass inside the 1-m-tall exclosure is not grazed by cattle, it remains tall (how tall?) during the growing season. Once the grass lodges during the winter, horizontal juniper would be exposed to browsing by deer. These juniper may experience a combination of stresses: reduced light availability during the growing season and browsing during the winter. Because juniper is common outside the exclosure, we can assume that it was present inside the exclosure at the time of construction in 1988. As grass grew more robust due to the absence of livestock grazing, the browsed juniper inside the exclosure may have declined.

The juniper in the 2-m-tall exclosure are robust and have the highest growth rate of four juniper areas that were measured. Even though the grass grows tall, unbrowsed juniper may be able to compensate for reduced light availability during the growing season. Outside the exclosure, grass is short and juniper would not be shaded during the growing season. Although the growth rate of juniper has been reduced by browsing, the plants persist.

Summary

Browse plants at TRMR experienced light-to-moderate browsing that enabled aspen, Bebb willow, and other browse plants to grow to the stature typical of their species. Beginning in the early 1970s, browsing pressure increased to intense, preventing plants from growing to typical stature. The data collected indicate that, in different areas, the increase in browsing intensity occurred at different points in time. Perhaps additional data would result in more consist timing. But there are unequivocal differences that indicate true between-site and between-species differences. For example, aspen at the Lenstra site were not intensely browsed until the late-1980s/ early 1990s, while chokecherry (at Upper Creek Bottom) was intensely browsed by the mid-to-late 1970s. The data clearly indicate that the current condition of browse is markedly different from the condition that existed prior to 1970.

Literature Cited

Keigley, R.B. and M.R. Frisina. 1998. Browse evaluation by analysis of growth form. Montana Fish, Wildlife & Parks. Helena, MT. 149 pp.

2000 Annual Report
Hosing Pasture Browse Study

Richard B. Keigley and John T. Ensign

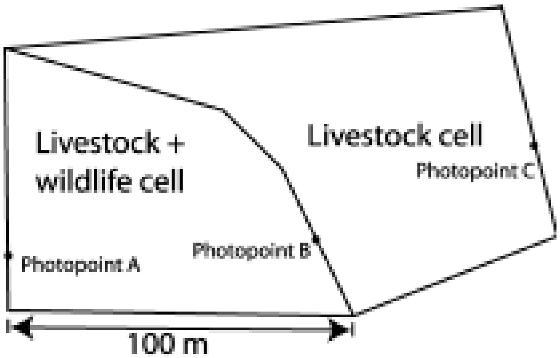
Introduction

In eastern Montana, woody draws are a source of browse for mule deer, whitetail deer, and livestock. The woody draw shown in the photograph to the right is located on BLM land about 25 miles north of Terry, Montana (47° 5.34N 105° 37.36W; T15N R48E sec 3). The browse species in this woody draw include aspen, green ash, chokecherry, serviceberry, silver buffaloberry, and hawthorn.

As shown in the photograph to the left, some chokecherry and serviceberry plants have attained statures ranging to three meters tall.

In the photograph to the right, the chokecherry plants in the left foreground have been heavily hedged by browsing. Virtually all plants with terminal leaders within the browse zone have arrested- or retrogressed-type architecture.

The heavy browsing pressure raises two questions. First, will browsing prevent young plants from attaining full stature? Second, what is the relative role of livestock versus wildlife?



To address those questions, a two-celled exclosure was constructed during the summer of 2000. A fence designed to exclude both livestock and wildlife was constructed with 2.5-m-tall barbed wire; the fence designed to exclude only livestock was about 1.3-m-tall. The livestock + wildlife cell was about 0.5 ha in area, the livestock cell about 0.7 ha.

In a study such as this, it is important to distinguish between the effect of browsing and effects that are due to local environmental conditions, such as dry soil or exposure to high wind. Plants growing inside the livestock + wildlife cell will indicate the site growth potential for each species.

A comparison of plants inside the livestock cell with unfenced plants that are exposed to all ungulate browsing will indicate the relative role of livestock versus wildlife.

How the effect of browsing was measured.

Over the life of the study, the effect of browsing will be monitored by repeat photography, plant architecture analysis, and by measurement of net annual growth rate (NAGR).

Photography. Photographs provide a subjective record of long-term changes in vegetation. Three permanent photo points were established by referring to specific exclosure fence posts. The map on the preceding page indicates the approximate positions. Photo point A was located at the fourth steel post as counted from the west corner of the wildlife exclosure. Photo point B was located at the fifth steel post counted from the northwest end of the common fence separating the wildlife and livestock cells. Photo point C was located at the sixth steel post from the southwest corner of the livestock cell.

Architectural analysis. Plant architectures provide a record of past and present levels of browsing (Keigley and Frisina 1998). It was the observation of arrested-type architecture that led to concern about browsing pressure at the site. Close-up photographs of young, arrested-type plants will be taken to document intense browsing. An analysis of the relationship between plant age and architecture will be used to develop browsing histories.

Net annual growth rate (NAGR); how the data will be used. Net annual growth rate measurements indicate the rate at which young plants are growing within the browse zone. Based on measurements of NAGR, one can calculate the number of years required to attain some given height. Once that number of years is calculated, one can assess the probability that a stem would live long enough to attain that height. Consider the following example. First, it is found that a 50-cm-tall stem has a growth rate of 5 cm / year. Because deer and livestock are the principal ungulate browsers in the Hosing Pasture, a stem must grow to a height of about 1.5 m in order to escape browsing. The stem in this example must grow an additional 100 cm. At a rate of 5 cm / year, the stem must survive 20 years to grow through the browse zone.

Having determined the number of years required to grow out of ungulate reach, one can then assess whether the stem can survive long enough to do so. The lifespan of browsed stems can be estimated counting the number of annual rings at the base of stems that have apparently been killed by browsing.

Net annual growth rate (NAGR); how the measurements were taken. In 2000, net annual growth rate (NAGR; Keigley and Frisina 1998) was measured in three ways: 1) $NAGR_{total}$, 2) $NAGR_{L3}$, and 3) $NAGR_{50cm}$.

$NAGR_{total}$ is the height of the plant (measured to the base of current year growth) divided by the age of the stem at the base. The age of the stem at the base is determined from a count of annual rings from a section taken at the base of the stem. The resulting ring counts are recorded as A_s on the data sheet appendices.

$NAGR_{L3}$ is calculated as (L1 + L2 + L3) / 3. In the case of the 2000 data set, L1 represents growth in 1999, L2 in 1998, and L3 in 1997. The resulting NAGR value represents the average net segment length over the previous three years. $NAGR_{L3}$ can be measured quickly and precisely, and (unlike the other NAGR measurements) is non destructive.

$NAGR_{50cm}$ is the growth rate experienced by the stem as it grew from ground level to 50 cm tall. $NAGR_{50}$ is calculated by: $50 / (A_s – A_{50})$, where A_{50} is a count of annual rings from a section taken 50 cm above the ground.

$NAGR_{total}$ reflects the average growth rate experienced over entire life of the plant. $NAGR_{L3}$ reflects the growth rate experienced during the most recent three years. $NAGR_{50cm}$ reflects the growth rate experienced when the plant first grew until the time the stem reached 50 cm. If snow cover protected the stem early in its life, $NAGR_{50cm}$ would be expected to be greater than growth rates experienced when the plant was taller and fully exposed to browsing. Although other factors must be considered (such as the relationship between stem maturity and growth rate), $NAGR_{50cm}$ provides an indication of how browsing may have affected growth rate at the site.

In 2000, the NAGR of two species was measured: chokecherry and serviceberry. Within each treatment, twenty plants of each species were selected for measurement. From each plant, the tallest stem (as measured to the base of current-year-growth) was selected for measurement.

Results / Discussion

Photography. Five series of panoramic photographs were taken. The first series (00-07-01 through 00-07-08) was taken from photo point A. The photographs sweep from E-S-W.

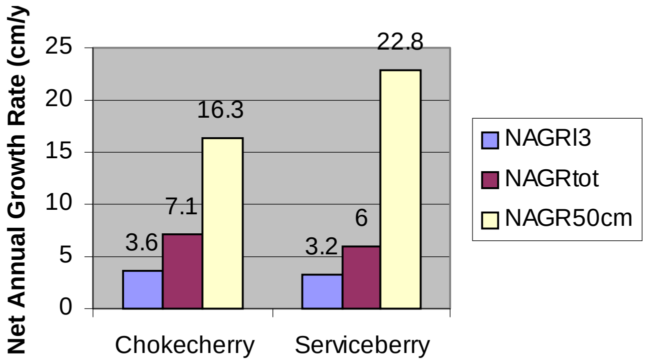
The second series (00-07-09 through 00-07-13) was taken from photo point B. The photographs sweep W-N-E inside the wildlife exclosure. An example from this series is shown to the right (00-07-12).

The third series (00-07-14 through 00-07-19) was also taken at photo point B. The photographs sweep W-S-E.

The fourth series (00-07-20 through 00-07-26) was taken from photo point C. The photographs sweep W-N-E inside the livestock cell. Photographs 00-08-01 through 00-08-07, also taken at photo point C, sweep W-S-E outside the cell.

The photographs will primarily be useful to document long-term qualitative changes that may occur.

Net annual growth rate (NAGR). The NAGR data, presented in full in the appendix, are summarized in the graph to the right. The respective NAGRs of both species are similar, indicating that browsing affects both species in a similar way.



With an average current-year-growth height of 61.6 cm (see summary appendix), chokecherry plants must grow an additional 88.4 cm to escape ungulate browsing. With an average $NAGR_{L3}$ of 3.6 cm / year, the stems must survive an additional 24.6 years to attain that height. With an average age of 9.5 years, the stems must survive to an age of 34 years. Once we determine the lifespan of heavily browsed stems at this site, we can assess the probability that chokecherry stems will survive long enough to attain full stature.

Based on an average current-year-growth height of 65.9 cm, serviceberry plants must grow an additional 84.1 cm to escape browsing. With an average $NAGR_{L3}$ of 3.2 cm / year, the stems must survive an additional 26.3 years to escape browsing. With an average of 11.4 years, the stems must survive to a total age of 37.7 years.

The above scenarios are based on average site values. The scenarios do not take into account the fact that the NAGR of some plants is greater than average, and that, for stand regeneration to occur, not all plants must attain full stature. To realistically assess we must consider the factors that control NAGR, including browsing effects (direct and indirect), environment, and stem age.

Browsing has both direct and indirect effects on growth rate. The obvious direct effect is simply due to the fact that ungulates consume material that could have been a segment of the plant's stem. Physiological stress is a known growth factor, and the excessive reduction of biomass would be a source of stress. Stem age is another factor that controls growth rate. In general, stems grow fastest when they are young; growth rate slows with maturity. When ungulate effects reduce stem growth rate, the stem may reach maturity while the terminal leader is well within the browse zone. As a result, the stem's exposure to browsing influences is exacerbated. Finally, environment influences at the Hosing Pasture may significantly contribute to the measured growth rates.

The $NAGR_{L3}$ values indicate growth rates in the most recent three years. With average L_3 growth rates on the order of 3 cm / year, $NAGR_{L3}$ describes—on average—growth conditions 9 cm below the height of current-year-growth (about 64 cm). In contrast, stems grew from ground level to 50 cm tall at average rates of 16.3 (chokecherry) and 22.8 (serviceberry) cm / year. A comparison of $NAGR_{L3}$ with $NAGR_{50cm}$ indicates that there was a significant reduction in growth rate over a relatively small vertical distance. The abrupt reduction in growth rate suggests that browsing was an important initial influence that, once initiated, may have been compounded by age-related influences.

In future years, we will be able to distinguish between livestock and wildlife effects by comparing the growth of plants inside the livestock cell with plants exposed to browsing by all ungulates. In addition, we will be able to assess the effect of local environmental conditions by examining plants protected from all ungulate browsing inside the wildlife cell. Because ungulate-induced stress may be apparent for some years following protection from browsing, we can anticipate that it will be some years before $NAGR_{L3}$ values may increase markedly. Measurements inside the wildlife cell will also indicate the effect of rodent herbivory—an effect that may be significant.

It should be noted that the stem ages determined from annual ring counts are an estimate. In the case of the Hosing Pasture stems, one can see a dramatic reduction in ring width that appears to correspond with an increase in browsing. When stem elongation is limited to a few centimeters, it seems likely that little biomass is available for an increase in stem girth. I often interpreted as annual increments, ring widths that were about two cells wide. The accuracy of such measurements is questionable.

In contrast, the measurement of L1, L2, and L3 segment lengths provides an accurate means of determining growth rate over the past 3 years. NAGR values on the order of 3 cm per year are extremely low.

Literature Cited

Keigley, R.B. and M.R. Frisina. 1998. Browse evaluation by analysis of growth form. Montana Fish, Wildlife & Parks. Helena, MT. 149 pp.